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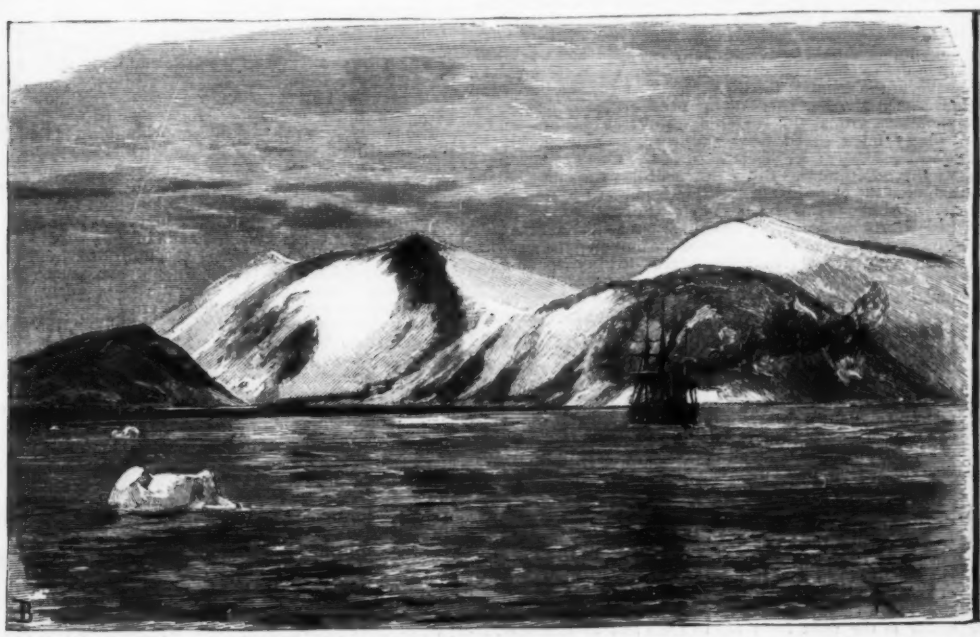
RESULTS OF THE GREELY EXPEDITION.

To the Associated Press agent, Lieutenant Greely stated the object of the expedition to be to establish at Lady Franklin Bay a Polar station, one of the thirteen suggested by Lieutenant Weyprecht. Simultaneous observations of all physical phenomena were to be taken. The observations in which the greatest possible accuracy was to be had were those of the declination and deviation of the magnetic needle, temperature of the air and sea, height of barometer, and mean and maximum rise and fall of tides. On the 28th day, and devoted the remainder of the time to amusement. All slept in bunks.

The quarters were heated by a large coal stove, the average heat maintained being 50 degrees above zero. Playing checkers, cards, and chess and reading were the amusements of the evening. The life was said by Lieutenant Greely to be far from a lonely one, and many of the men said they had never passed two happier years than those passed at Fort Conger. On October 15 the sunlight left them for 135 days, and a twilight varying from half an hour to twenty-four hours succeeded. For two months it was so dim that the dial of 12 days at a time. The thermometer registered on June 30, 1882, the highest temperature at Lady Franklin Bay which was known during the stay. It was 52 degrees above zero. The lowest was in February, 1883, and was 66 degrees below zero. In this February the mercury froze and remained solid for fifteen days, so intense was the cold. The mercury in the thermometer invariably rose during storms or high winds.

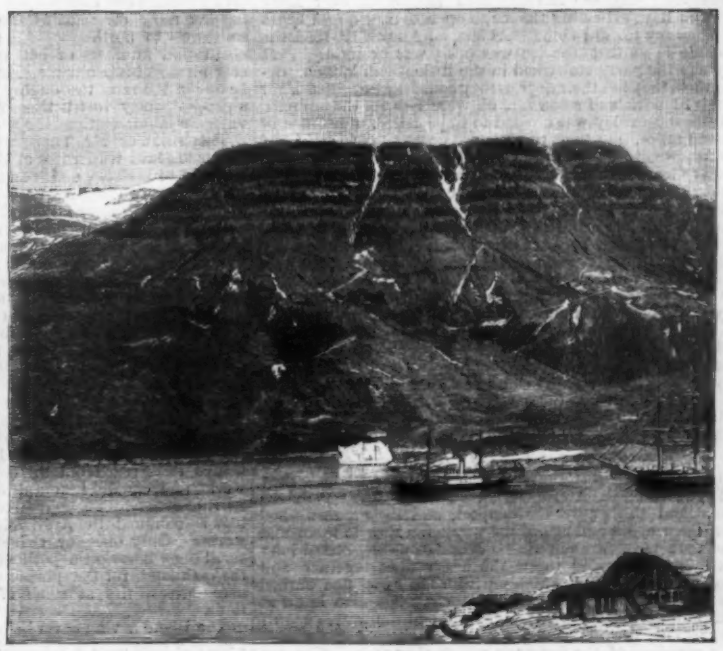
The highest barometer was slightly above thirty-one inches and the lowest slightly below twenty-nine inches, showing a great range. The greatest variations were in the



COAST OF IVSUGIGSOK, CAPE YORK

HANS HENRIK, AN ESQUIMAU INTERPRETER AND GUIDE

THE DANISH COLONY AT GODHAVN, GREENLAND.



DISCO ISLAND, GREENLAND.

THE GREELY ARCTIC RELIEF EXPEDITION.—SCENES ON THE ROUTE.

of August, 1881, the parting between the Greely party and the men of the Proteus took place at Discovery Bay. On the evening of the same day the temperature sank below the freezing point, and the icy Arctic wind was on them in earnest. During the first month the cold affected the men more than at any subsequent time. Later on in December the temperature sank from 50 to 65 degrees below zero and so remained for days at a time, but even in that weather the cook's favorite amusement was dancing bare-headed, bare-armed, and with slippered feet on the top of a snow drift. During the day the men dressed in the ordinary outside clothing, but their flannels were heavy. Five of the men were generally for a part of the day engaged in scientific work under Lieutenant Greely's direction, and in the duties of the camp; the rest of the men were employed generally about one hour a a watch could not be read by it. On April 11 the sun came above the horizon and remained there for 135 days, giving the party a great sufficiency of midnight sun. During three months the stars were visible constantly, the constellations of Orion's Belt and the Great Bear being the brightest. The North Star looked down from almost overhead. Standing alone outside the fort on one of these nights the scene was weirdly grand. To the north flamed the aurora borealis, and the bright constellations were set like jewels around the glowing moon. Over everything was dead silence, so horribly oppressive that a man alone is almost tempted to kill himself, so lonely does he feel. The astronomer of the party said that with the naked eye a star of one degree smaller magnitude than can be seen here in the same way might be discerned. The moon would remain in sight for from 1 to winter. The electrometer, an instrument used to ascertain the presence of electricity, was set up; but, to the astonishment of Lieutenant Greely, not the slightest results were obtained.

THE AURORA AND THE STARS.

The displays of aurora were good, but not to be compared with those seen at Disco Island or Upernavik. As far as Lieutenant Greely could observe, no crackling sound accompanied the displays, and the general shape was that of a ribbon. The southwesterly horizon was the quarter in which the brightest displays were seen. Sir George Nares reported in 1876 that no shadow was cast by the aurora, but Lieutenant Greely says that he distinctly observed his shadow cast by it. There were no electrical disturbances save those

manifested by a rumbling of distant thunder heard twice far away to the north.

In the course of the tidal observations made, an interesting fact was discovered—that the tides of Lady Franklin Bay came from the north, while those at Melville Bay and Cape Sabine came from the south. The temperature of this north tide was two degrees warmer than that of the south tide at Cape Sabine. Why this was Lieutenant Greely would not venture to state. He used in measuring the ebb and flow of the tide a fixed gauge—an iron rod planted in the mud. The average rise of spring tides at Lady Franklin Bay was found to be eight feet. At Cape Sabine the highest tides rise twelve feet. Surf was only observed twice during the two years. At Lady Franklin Bay the average temperature of the water was 29 degrees above zero, or three degrees below the freezing point. Wolves weighing ninety pounds were killed around Fort Conger, and there are foxes and other animals there. Of fish there is a wonderful scarcity. Perhaps the greatest surprise of the expedition was the taking from Lake Alexander, a fresh water lake fifteen feet above the sea level, a four pound salmon. From the bay or sea only two small fish were taken during the entire two years, and few are to be found north of Cape Sabine. The vegetation at Lady Franklin Bay was about the same as at Cape Sabine, and comprised mosses, lichens, willows, and saxifrage. Snow storms were frequent, and rain fell rarely. The highest velocity of the wind was registered during a terrific snow storm—seventy miles an hour. Lockwood's trips to the North in 1882 and 1883 were productive of the most valuable results. Standing on the 19th of May in each year where Dr. Hayes had formerly stood at about the same day, Lockwood from an elevation of 2,000 feet, using his strongest glass on Hall's Basin and Robeson's Channel, could discern nothing but ice packs. Here it was Dr. Hayes claimed to have seen his open Polar sea.

FURTHEST POINT NORTH REACHED.

On the trip of 1882 Lockwood reached the highest latitude ever attained—83° 25′ N. This was about 300 miles directly north of Lady Franklin Bay, but to get there he traveled over 1,000 miles, the open water and broken packs frequently causing him to retrace his steps 50 miles. Lockwood sounded the sea both years between Cape Bryant and Cape Britannia, but could not touch bottom with 135 fathoms of line. Markham a few years before, about 100 miles to the west, got bottom at 72 fathoms. Lockwood found at his furthest north about the same vegetation as at Lady Franklin Bay, but no signs of a Polar current or open Polar sea. In 1883 he was stopped near Cape Bryant, 125 miles from Lady Franklin Bay, by an open channel extending west to the coast of Grinnell Land. The width of this channel varied from 200 yards to five miles, but on the north the ice-packs extended as far as could be seen with a glass. With his supply of provisions, the failure of which had caused his return the year before, Lockwood was confident that he could have reached 85° north, if this open channel had not barred his way. No fossil remains were discovered on this trip, and the only ones found were the trunks of trees on the southwest coast of Grinnell Land. The only sea animals seen by Lockwood at 83° 25′ were the walrus and seal, and, strange to say, the walrus is not to be found at Lady Franklin Bay. At 83° 25′ the deflection of the magnetic needle was 104° west—more than one-quarter of a circle.

As far as Lockwood went, the northeastern trend of the Greenland coast still continued. The maps of the new regions he discovered are in the possession of Lieutenant Greely, and are carefully made. All through the two years at Lady Franklin Bay the magnetic needle was never quiet except during storms. In February, 1883, preparations for the retreat were made by establishing a depot at Cape Baird, twelve miles to the south.

Day after day the anxious men looked off over Lady Franklin Bay, expecting the ice to open, so they might begin their journey toward home. At last, on August 19, 1883, the welcome news that the ice was open was brought. That very day the party embarked in the little steam launch. Behind them they left their dogs, as they could not be taken. Four barrels of pork and some seal oil were left for the animals. Lady Franklin Bay was crossed to Cape Baird, a distance of thirteen miles, and then the western coast of Grinnell Land was followed south as far as Cape Hawkes. Large quantities of heavy ice were met, and extreme was the danger that every moment the little launch would be crushed. Several times all the boats were nearly lost. The suffering of the men was great. They were now within fifty miles of Cape Sabine. Striking from Cape Hawkes direct for Bates Island, the party was caught in the ice pack and frozen in, ten miles south of Cape Hawkes. In thirteen days they drifted south twenty-five miles on the floes, suffering horribly from the cold. So they drifted to within eleven miles of Cape Sabine, and were obliged to abandon the steam launch on September 10. The pack now remained motionless for three days, and several times the party got within two or three miles of Cape Sabine, only to be drifted back by southwest gales. Five seals were killed and eaten while the party were drifting about. Eventually a heavy northwest gale drove them by Cape Sabine, within a mile of Brevoort Island, but they could not land.

GREAT GALE IN THE ARCTIC.

On September 22 there arose the most terrible gale they had yet seen on the Arctic Ocean. Their ice floe was driven hither and thither by the tempest, and the waves washed over them again and again, the spray freezing to them and causing them intense suffering. Night came on—one of inky blackness. The wind threw the heavy floes together, and crash after crash of ice breaking from their own floe warned the men that death was near to them. No man knew at what minute the floe might break up and the waters engulf them. The first faint light of dawn showed them that little remained of the floe upon which they were. The sea washed another close to them. Closer it came, and at last, at the word, the men succeeded in getting upon it. The storm slowly subsided, and they gained land at Esquimau Point, near Baird's Inlet, on September 29.

Here winter quarters were built, and scouts were sent to Cape Isabella and Cape Sabine. In a few days they returned. Their report sent a thrill of horror to every heart. At Cape Isabella and Cape Sabine were found only 1,800 rations, and from Garlington's records they learned the fate of the Proteus. Every one knew that death must come to nearly every one of the party long before the ship of rescue could force its way into Melville bay. Efforts were made to sustain the spirits of the men by lectures and light reading. On October 15 the party removed to Cape Sabine. On January 18 Cross died of scurvy. In April the rations issued had dwindled to four ounces of meat and six ounces of bread. Man after man died and all hope had fled when, on that stormy day, the blast of the Thetis' whistle roused the survivors from the lethargy of approaching death.

Lieutenant Greely, when asked as to his ideas upon the probable results of Arctic explorations, said: "I do not think the North Pole can be reached unless every circumstance hitherto found to be unfavorable should prove favorable to the party attempting to reach the Pole. If it is to be done at all, it will be done by way of Franz Josef Land. It could never have been reached by the Jeannette's route. That there is an open Polar sea I am well nigh certain. This is proved by the ice drifting out of Mussel Bay and Spitzbergen in mid-winter, and the northern drift of the Polar pack experienced by Pavy and Lockwood in 82° 83′. Men can stand two winters very well at Franklin Bay, but physical strength rapidly deteriorates. If we had had every supply and food, we could have lived perhaps eight or ten years at Lady Franklin Bay."

[NATURE.]

ICELAND.—MR. THORODDSEN'S GEOLOGICAL EXPLORATIONS.

ALTHOUGH situated at a comparatively short distance from Europe, and notwithstanding the frequent visits of late years by English tourists, Iceland is yet very far from being a well known country. The upland is still, for the most part, an unexplored region, and there are whole districts where no man, native or foreign, ever set his foot, owing chiefly to the difficulties and dangers which attend traveling through these wildernesses. Foreigners travel mostly along beaten tracks; they come mostly without having acquired any previous knowledge of the peculiar nature of the country, consequently not knowing what parts are most worth visiting or exploring. Yet these regions are eminently interesting for students of natural science, being filled with innumerable glaciers, some of enormous magnitude, with multitudes of volcanoes, eruptive springs, etc., which it is of the greatest importance should be scientifically explored and described. In order to obtain reliable information about these upland wilds of the country, the Government of Iceland have commissioned Mr. Th. Thoroddsen to undertake systematic explorations with a view to establishing the geology of the country on a sound basis, and correcting its geography where necessary; for this purpose he has already undertaken various expeditions. In the course of last summer (1883) he explored the peninsula of Reykjanes and its upland connections. Although this part lies in close proximity to the inhabited parts of the country, it has hitherto remained for the most part a *terra incognita* on account of the innumerable waterless and utterly barren lavas which are crowded into it, and make traveling excessively arduous. Formerly people only knew that within historic times two volcanoes had been active in these parts. Mr. Thoroddsen has now determined the existence and site of no less than *thirty* separate volcanoes with at least *seven hundred* craters. In each case he has made all necessary measurements, and has constructed a geological map of the whole district.* The aggregate extent of the lavas covers about 44 square (geographical) miles. Out of the lavas up and down this tract there rise mountains composed of tufa and breccia, and through these the eruptions of the volcanoes proper have found their vent. Cases of individual volcanoes being built up in one spot by repeated eruptions are rare. The craters are in most cases traceable in distinct long rows, like pearls on a string, along terraces of tufa, situated along chasms through which the lava welled out. In some places there are no craters, the lava having boiled out of the chasm over either side of it, in which cases the rift remains open with its brims covered with a glazed crust of lava. In other localities are found volcanoes of colossal size, broad sublevations or convexities of lava, with a large crater at the apex from 800 to 1,000 feet in diameter, instances of which are Skjaldbreid, 3,400 feet, and Heidin-Ha, 2,000 feet above the level of the sea. Throughout the lava stretches one comes upon enormous fissures all following the same direction as the rows of the craters, namely, southwest to northeast. All about this district there are also found numbers of hot springs, solfataras, and boiling clay pits. This peninsula, Mr. Thoroddsen maintains, must be one of the most thoroughly burnt spots on the globe, and a pre-eminently instructive tract for geologists who make volcanic manifestations the specialty of their study.

This summer Mr. Thoroddsen is engaged exploring the enormous lava wilderness of Odadahraun, covering the central part of Iceland, and, as yet, for the most part entirely unknown. In the glaciers to the south of this wilderness great eruptions have taken place of late years, about which nothing is known, no one having as yet ventured into these wilds, lying 3,000 to 4,000 feet above the level of the sea. The difficulties of exploration here are enormously aggravated by the utter barrenness of the region, by scarcity of water, and by the frequent snow tempests by which the region is constantly harried even in the midst of summer. Even the compass is not to be relied upon, on account of the mass of iron which enters to such a large extent into the composition of the lava.

Akreyri, June 24, 1884.

Grimsey is the name of a small island, situated in the Arctic Ocean, about 22 English miles due north of the promontory which divides the bays of Eyjafjord and Skagafjord in Northern Iceland. It is inhabited by 88 human beings, debarred from all communication with the outer world, and equally ignorant of its motive thought as of its stirring events. Their intercourse with outward surroundings is confined to Arctic ice and ceaselessly recurring storms. Only once or twice a year they manage in their small open boats, at a perilous risk, to effect a landing on the mainland, for the purpose of obtaining by barter their necessaries of life at some of the north coast trading stations.

The island having never before been visited by a naturalist, I eagerly embraced the opportunity of joining the governor of the North District on an expedition to it, undertaken at the instance of the commander of the gun boat Diana, Capt. O. Irminger, of the Danish navy. On the evening of June 19 we steamed, in calm weather, from Akreyri down the broad bay of Eyjafjord, enjoying the imposing scenery of the mountains on either side, lit up by the subdued vermilion tints of the nocturnal sun glare; when we reached the mouth of the bay, we had a full, unintercepted view of the midnight sun, resting on the oceanic sky-line, like a ball of fire behind a veil of blood. Out of the inert calm of the deep, which looked like polished glass, there rose on either side of us black precipitous rocks that formed, as it were, the advanced basis of the snow-capped mountain tops, which determined our sky-line in the landward distance.

We reached Grimsey at three o'clock in the morning of the 20th, still, as good luck would have it, favored by the same calm weather and quiet sea—both being the indispensable conditions of effecting a safe landing on the island. We took the shore just below the parsonage in a bight formed of precipitous rocks made of basaltic columns, here and there split up by yawning caves; and having succeeded in clambering to the top of the rocks, we set about exploring the island.

The formation of Grimsey is basaltic throughout, and, geologically speaking, resembles, closely on the whole, the stratification of Northern Iceland. From its non-volcanic nature one may therefore fairly assume that, once upon a time, it must have been connected with the mainland. But though not volcanic itself, it seems that Grimsey is not very far removed from the lines along which the active subterranean fires in Iceland are operating. At various times the inhabitants state they have observed toward the southeast signs of submarine volcanic action, and toward Tjornes (S.S.E.) a column of fire was distinctly observed breaking through the surface of the sea in 1868; this, too (one of the northernmost promontories of Iceland), has frequently been visited by violent earthquakes, notably so in 1872. Toward the east the island rises precipitously out of the sea to the height of upward of 300 feet, but slopes to the westward, where all the habitations of the people are scattered about. The flora is scanty, and the plants stunted in a remarkable degree; as far as I had opportunity to observe, the vegetation seemed to bear a distinct Arctic impress as compared with that of the mainland. The sward is covered with Arctic willow (*Salix herbacea*), resembling the same plant when met with on the mainland at an elevation of 1,500 to 2,000 feet above the sea level. The flora of the eastern portion of the island is much more varied, as compared with that of the western, owing to the soil being much more fertile there from the guano deposited by the multitudes of birds which haunt that part of the island. Every ledge of rock is covered with the so-called "Skarfa-kal" (scurvy-kale, scurvy-grass, or spoon-wort, *Cochlearia officinalis*). Altogether I managed to collect here between fifty and sixty species of plants, all of which are also found on the mainland, only these are of a more stunted growth. No heath vegetation occurred, and no ligneous, if I except the above mentioned willow, which only grows to the height of one inch and a half.

The temperature of Grimsey is much milder than might be supposed from the geographical position of the island. Although it is visited every two out of three years by the Arctic ice, the average temperature of the year is + 1·4° Celsius. August is the hottest month in the year, +7½° C.; March the coldest, —3½° C. The highest degree of heat in 1876 was +20° C.; the greatest cold in 1880, —30° C. The mildness of the temperature is accounted for by the fact, ascertained of late years beyond a doubt, that a small branch of the Gulf Stream splits off from the main current on encountering the resistance of the western submarine spurs of the rocky masses on which Iceland is built up, the flow of which branch, on wheeling round the northwestern peninsula of the country, takes an eastward direction along the whole extent of the northern coast. The average temperature of the sea round Grimsey is about 4° C. in January and 3° C. in February. The pastor of the island, M. Pjetur Gudmudssen, has for many years been engaged in exceedingly careful meteorological observations on behalf of the Meteorological Institute of Copenhagen. This most worthy gentleman, living here in conspicuous poverty, like a hermit divorced from the world, though he has the comfort of a good wife to be thankful for, is not only regarded as a father by his primitive congregation, but enjoys moreover the reputation of being in the front rank among sacred poets in modern Iceland.

The inhabitants derive their livelihood for the most part from bird-catching, nest-robbing, and deep-sea fisheries. The precipices that form the eastern face of the island are crowded with myriads of various kinds of sea-fowl. On every ledge the birds are seen thickly packed together; the rocks are white with guano, or green tufted with scurvy grass; here everything is in ceaseless movement, stir, and flutter, accompanied by a myriad-voiced concert from screamers on the wind, from chatterers on domestic affairs in the rock-ledges, and from brawlers at the parliament of love out at sea, the surface of which beneath the rocks is literally thatched at this time of the year with the wooing multitudes of this happy commonwealth. If the peace is broken by a stone rolled over the precipice, or by the report of a gunshot, the air is suddenly darkened by the rising clouds of the disturbed birds, which, viewed from the rocks, resemble what might be taken for gigantic swarms of bees or midges.

The method adopted for collecting eggs is the following: Provided with a strong rope, some nine or ten stalwart men go to the precipice, where it is some 300 feet high, and one of the number volunteers or is singled out by the rest for the perilous "*sig*," *i. e.*, "sink," or "drop," over the edge of the rocks. Round his thighs and waist, thickly padded generally with bags stuffed with feathers or hay, the "*sigamadr*," "sinkman," or "dropman," adjusts the rope in such a manner as to hang, when dropped, in a sitting posture. He is also dressed in a wide smock or sack of coarse calico, open at the breast, and tied round the waist with a belt, into the ample folds of which he slips the eggs he gathers, the capacity of the smock affording accommodation to from 100 to 150 eggs at a time. In one hand the "sinkman" holds a pole, 16 feet long, with a ladle tied to one end, and by this means scoops the eggs out of nests which are beyond the reach of his own hands. When the purpose of this "breath-fetching" "sink" is accomplished, on a given sign the "dropman" is hauled up again by his comrades. This, as may readily be imagined, is a most dangerous undertaking, and many a life has been lost over it in Grimsey from accidents occurring to the rope.*

For the pursuit of the fishery the island possesses fourteen small open boats, in which the men will venture out as far as four to six miles codfishing; but this is a most hazardous industry, owing both to the sudden manner in which the sea will rise, sometimes even a long time in advance of traveling storms, and to the difficulty of effecting a landing on a harborless island.

Now and then the monotony of the life of the inhabitants is broken by visits from foreigners, mostly Icelandic shark-fishers, or English or French fishermen.

Of domestic animals the islanders now possess only a few sheep. Formerly there were five cows in the island, but the hard winter of 1860 necessitated their extermination, and since that time, for twenty-four years, the people have had to do without a cow! Of horses there are only two at present in the island! Strange to say, the health of the people seems, on the whole, to bear a fair comparison with more favored localities. Scurvy, which formerly was very pre-

* Published by the Geological Association of Stockholm.

* This is a fate that befalls too many of the "sinkmen" of Iceland, for there are numbers of them all round the coast. It would be easy, at a very small cost to the treasury of Iceland, to provide a perfectly safe movable apparatus for every district where life must be sustained at the above described risk. The authorities would, no doubt, readily meet any reasonable request on the subject.—E. M.

valent, has now almost disappeared, as has also a disease peculiar to children, which in the form of spasm, or convulsive fit, used to be very fatal to infant life in former years.

Inexpressibly solitary must be the life of these people in winter, shut out from all communication with the outer world, and having in view, as far as the eye can reach, nothing but Arctic ice. The existence of generation after generation here seems to be spent in one continuous and unavailing Arctic expedition. The only diversion afforded by nature consists in the shifting colors of the flickering aurora borealis, in the twinkling of the stars in the heavens, and the fantastic forms of wandering icebergs. No wonder that such surroundings should serve to produce a quite, serious, devout, and down-hearted race, in which respect the Grimsey men may perhaps be said to constitute a typical group among their compatriots. However, to dispel the heavy tedium of the long winter days, they seek their amusements in the reading of the Sagas, in chess-playing, and in such mild dissipations at mutual entertainments at Christmas time as their splended poverty will allow.

TH. THORODDSEN.

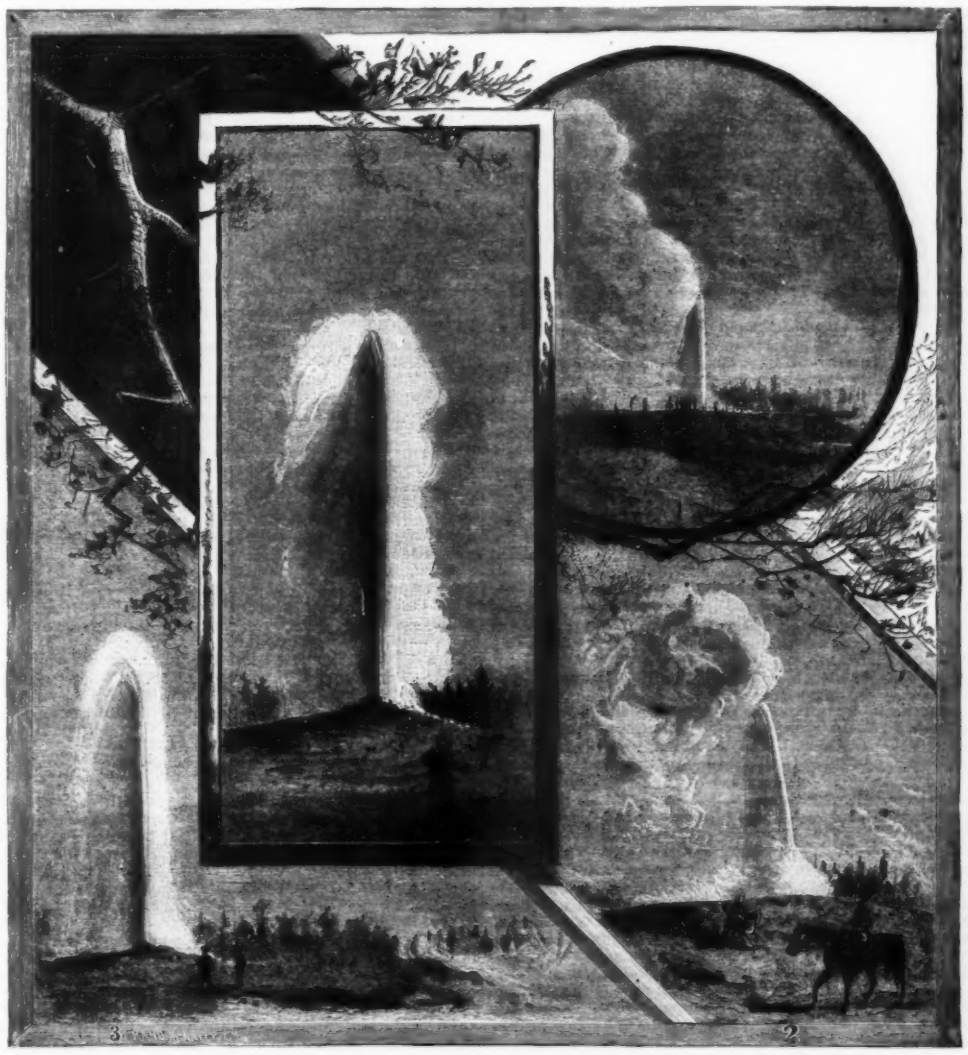
YELLOWSTONE NATIONAL PARK.

THE Yellowstone National Park is situated in the most elevated part of that portion of the Rocky Mountains lying in the extreme northwest quarter of the Territory of Wyoming, the northeastern portion of Idaho Territory, and the southern part of Montana Territory. By Act of Congress, this section of country, about 200 square miles, is perpetually dedicated to the use and pleasure of the people as a National Park.

One of our illustrations represents the extreme western end of the Yellowstone Valley, with the "gateway" of the cañon through which you pass to enter the park in the distance, some fifty miles to the south. Numbers 1 and 2 represent the "Old Faithful" geyser, a brief description of which will be of interest to our readers.

The principal geysers of the park are in the Upper Geyser Basin, which extends from "Old Faithful" down the main Firehole River to a point just below the mouth of the little Firehole river, and along Iron Spring Creek, a branch of the latter stream. The more important springs and geysers are on the main river. As the Firehole and Little Firehole rivers converge, flowing northward, the basin is almost triangular in shape. The extent of the basin is about four square miles, but the chief geysers are situated within an area of perhaps half a mile along the course of the Firehole on either side of the stream. This flows from southeast to northwest through the basin, taking a more northerly course, however, after the waters of Iron Spring Creek and the Little Missouri unite with it. The volume of the Firehole is sometimes greatly increased just after the eruption of some of the larger geysers, and the temperature of the water is affected by the springs. For example, at the distance of a quarter of a mile from "Old Faithful" to a point opposite the "Grand Geyser," the river has been found seven degrees Fahrenheit warmer. The surface of the Basin consists of a succession of ridges and knolls, crowned with geysers and boiling springs. On every side are mountains 1,500 feet or more in height, the slopes of which are heavily timbered, although there are occasional outcroppings of rough basaltic rocks among the pines. Clouds of steam hang as a pall over the basin, and columns of vapor float upward like water wraiths from between the tree-trops of the surrounding forest. The earth is full of rumbling and gurgling sounds, and the air is laden with sulphurous fumes. Stupendous fountains of boiling water veiled in spray shoot toward heaven at varying heights, like cascades reversed, glinting and coruscating and scintillating in the sunlight until their force is expended, when they fall in showers of flashing pearls with a shock that shakes the ground. An excellent point from which to obtain a comprehensive view of the Upper Geyser Basin in a high mound near "Old Faithful," formerly the crater of a geyser, of which nothing now is left save a small steaming, gurgling vent. Here the entire band of geysers may be seen and heard as they give their concert with hot water trumpets in perfect diapason, each performer at irregular intervals taking a solo part, and uttering his loudest tones in harmonic combination. Close at hand on the right is "Old Faithful," which regularly every hour sends its stream of boiling water 160 feet upward, and continues this spectacle for the space of five long minutes. This grand exhibition is alone sufficient to satisfy the expectations of the most exacting sight-seer. But there are besides many other geysers of greater power. In the foreground looms the "Castle," looking like a feudal stronghold, belching forth its pearl-white clouds of steam and heavy jets of boiling water. To the right, across the river, is the "Beehive," which often twice a day sends forth a lordly column 219 feet in height from its shapely crater. A few rods beyond is the "Sapphire Pool," out of which the "Giantess" plays fortnightly her stupendous fountain. Close by are the "Lion," the "Lioness," and her two "Cubs," each of which, when roused to action, inspires terror by its growling.

This remarkable region of the Yellowstone, before whose geysers all others of the world—even the celebrated ones of Iceland—sink into insignificance, is now made easily accessible by the Northern Pacific Railroad.—*London Graphic.*



1 and 2. "Old Faithful" Geyser in Action, Night and Morning.—3. "Beehive" Geyser: Sends up a Column of Water 219 Feet High every Eight Hours.—4 "Grand" Geyser: Throws a Stream 200 Feet High at each Eruption.

THE USEFUL MINERALS AND ROCKS.

CHRYSOLITE is a silicate of magnesia and iron ranging from pale green to olive in color. Its hardness is a little less than quartz. The pale yellow variety is made into necklaces and other ornaments. Peridot is a yellow green chrysolite. Chrysolites are seldom used as ring stones. They appear to have been more highly valued by the ancients than at the present time.

Most chrysolites used in jewelry come from the countries of the Eastern Mediterranean, though good specimens have been found in Arizona, New Mexico, and other parts of the west.

Lapis lazuli, or azure-stone, is a mineral of uncertain composition, partly a silicate of alumina, lime, and soda. It is an opaque stone of a beautiful azure-blue color, and somewhat softer than quartz. It is used in jewelry for studs, brooches, and various other ornaments, sometimes as a ring stone. In the Eastern countries it is carved into vases and other ornamental articles. It is found in China, Persia, and Siberia, but has not yet been discovered in this country.

Amazon stone is a bluish green variety of the common kind of feldspar called orthoclase. In composition it is a silicate of alumina and potash. It is an opaque stone with a somewhat pearly luster and a hardness of 6 or 6·5, just below quartz. It is quite brittle, but takes a good polish. It was first discovered on the banks of the Amazon, from which circumstance it takes its name. It is found at Lake Baikal, in Siberia, and Pike's Peak, Colorado; also in North Carolina. It is mostly used in cheap jewelry.

Moonstone, or adularia, agrees in hardness and composition with Amazon stone. It has a pearly or silvery reflection not unlike that of the moon, from which it takes its name. It belongs to the cheaper grade of gems, though in some parts of Europe it has at times been much esteemed. The finest specimens come from Ceylon. It is found in this country at Media, Penn., and in Virginia.

Sunstone is like moonstone in composition and hardness. It is of a yellowish color, reflecting sparkles of light in various directions, owing to minute particles of iron oxide which are disseminated through it. It is found in Siberia, Norway, and Ceylon, and in the United States in the same localities as moonstone. It is also called aventurine feldspar.

Jade, or nephrite, is a variety of the common mineral hornblende of a greenish white or olive green color. Its composition is silica, magnesia, and lime; hardness, 6 to 6·5. It is semi-transparent or translucent, and though of moderate hardness is extremely tough and very difficult to cut and polish. It is little used or valued by Europeans, but is highly esteemed by the Chinese, who work it into elaborately carved cups, vases, images, and ornaments of all kinds. In ancient times it was extensively used for making hatchets, axes, and various utensils and ornaments, as is proved by the finding of buried specimens in many places in Europe and Asia. It has also been employed in making weapons of war, and even idols, by savage tribes, as in New Zealand and Mexico. It was called nephrite, from a Greek word, meaning kidney; because of a former belief in its efficacy in curing kidney diseases. It is found in China, Egypt, New Zealand, Mexico, and Peru.

Jadeite much resembles jade, though different in composition. Much of the jade found in China and Mexico is this stone. Both nephrite and jadeite are commonly included under the name jade. It has recently been found in Alaska. Though jade can hardly be called a precious stone, never having been greatly valued except by the Chinese, yet it seems proper to mention it here.

Labradorite or Labrador spar is a variety of feldspar of various shades, the kind used in jewelry having a rich blue color. In composition it is a silicate of alumina, lime, and soda, with a hardness of 6. It is remarkable for its beautiful play of colors, and its sparkling reflections like aventurine feldspar. Though generally blue, green, yellow, and red kinds are not uncommon, sometimes pearly gray. It is manufactured into snuff boxes, bracelets, etc., but seldom or never used as a ring stone. Labradorite was first found on the coast of Labrador toward the latter part of the last century, but has since been discovered in Norway, Sweden, Russia, Canada, and in this country in New York, Pennsylvania, and various other places.

Hiddenite is the name of a new gem lately discovered at Stony Point, North Carolina. It is a variety of the mineral spodumene, and in composition is a silicate of alumina and lithia. Hardness about 7. Its color is a beautiful emerald-green. A company is at present engaged in actively mining this gem, of which the demand exceeds the supply. This locality and the tourmaline mine at Paris, Me., are the only places where mining for gems is at present carried on in the United States. Hiddenite has not been found elsewhere.

We now come to the mineral quartz, which affords a greater variety of gems than any other known mineral, though they are mostly of the cheaper grades. Quartz is but another name for silica, a chemical compound of the two most abundant elements in nature, oxygen and silicon. Though not a silicate, which is a mineral containing silica with the addition of one or more of the other native elements, it seems proper to speak of it in their connections. Quartz is the most abundant constituent of the crust of the globe so far as known. It forms a large proportion of the substance of the most common rocks, as granite, gneiss, mica schist, sandstone, etc., and the milky and vitreous varieties of quartz must be familar to observers of nature in nearly all parts of the world, except, perhaps, those living in districts underlaid by extensive formations of slate or limestone. Quartz is the hardest of all common minerals, ranking 7 in the scale. It scratches glass easily, and breaks with an irregular to conchoidal fracture. Only a few of the precious stones are softer than quartz, and these, with the exception of opal, pearl, and turquoise, are not of great value. The luster of quartz is commonly vitreous, though some varieties are of a waxy or greasy luster. Its range of color is very extensive, owing to the presence of various impurities, most all hues, tints, and shades being represented—yellow, pink, red, purple, brown, gray, green, black, and sometimes blue. When pure, it is white or colorless.

Colorless or glassy quartz, when occurring in a perfectly transparent condition, is called rock crystal. It was believed in ancient times to be a kind of petrified ice, having been congealed by such intense cold that no ordinary heat was sufficient to melt it into water again. Its name was derived from a Greek word signifying ice. When properly cut, rock crystal considerably resembles the diamond, though lacking the adamantine luster and being much inferior in hardness. It is extensively used in rings, studs, and various kinds of cheap jewelry, generally going by the name of quartz-diamond. Its most important use is in the manufacture of lenses and spectacle glasses. Most rock crystal used for these purposes comes from Brazil, and is termed "Brazilian pebble."

Of all precious stones rock crystal is perhaps the most abundant and the cheapest, though not of the least commercial importance. It is found in nearly all sections of the globe. In Brazil, East Indies, Madagascar, Ceylon, Japan, Switzerland, Italy, Bohemia, and India. It is also found in many places in this country. Near Lake George and adjacent parts of New York State it occurs in fine crystals. These are extensively used in jewelry and are called "Lake George diamonds." Many so-called quartz diamonds, however, are nothing but glass. Rock crystals are found in large masses in North Carolina. It also occurs at Crystal Mountain, Arkansas, in Colorado, on the Jersey coast, and at various other places. In India and Japan this stone is cut into cups, vases, globes, and various elaborately carved ornaments. A variety which reflects the colors of the rainbow or prism, because of cracks or flaws in the interior of the stone, is called iris.

False topaz is a name applied to light yellow vitreous quartz because of its resemblance to topaz. Brazil is the principal locality for this stone. Smoky yellow or smoky brown transparent quartz is called Cairngorm stone, from the name of a noted locality in Scotland. It is commonly used for dirk handles, snuff boxes, and other ornaments of the Scotch Highlanders. Cairngorm is also found in Spain

and Brazil; and in this country, at Pike's Peak, Colorado, where large quantities are sold for use in jewelry. Said to occur at Magnet Cave, Arkansas, and in North Carolina. Brownish black Cairngorm is called morion.

Rose quartz is a transparent kind of a pink or light rose-red color. It is but little used in jewelry. It sometimes passes for spinel ruby.

Amethyst is rock crystal or transparent quartz of different hues of purple. It has always been extensively used as a ring stone. Though of slight value at present, it was formerly highly esteemed. The best amethysts are found in India and Persia. Also occur in Brazil and Siberia and in this country at many places, among which are Stowe and Paris, Me., Acworth, N. H., and Chester County, Penn.

Blue or sapphire quartz is rare. It is found in Auvergne, France, and in Austria.

Aventurine is a translucent quartz of various colors, reddish-brown, brown, green, but generally the former. It is thickly bespangled with minute scales of mica or copper, generally yellow, embedded in the quartz, which gives it a peculiar glittering appearance, and is the reason of its being often called gold stone. Many articles of ornament are made from it, and it is quite commonly used in rings, studs, earrings, etc. It is found in Siberia, Bohemia, and other parts of Europe. The green variety occurs in India.

Cat's eye quartz is a rare stone, occurring in small round pebbles, and generally translucent or transparent. Its color is commonly yellowish, greenish, or brownish, though sometimes red, olive green, or nearly black. When polished it has the appearance of containing a peculiar floating shape like the pupil of a cat's eye. This effect is supposed to be caused by the presence of fibers of asbestos. The cat's eye is perhaps the most valuable of all quartz stones. It is found in Bohemia and Bavaria, but the best specimens come from Ceylon.

Venus' hair stone is rock crystal, containing needle-shaped crystals of rutile. Found in North Carolina.

Prase is a green translucent kind of quartz, generally of a vitreous luster. Found in Saxony.—*Boston Journal of Commerce.*

[Continued from SUPPLEMENT No. 452, page 7222.]

THE ORIGIN OF BITUMENS.

By S. F. PECKHAM, A.M.*

IT is not the effects of heat, as represented by volcanic action, that have produced petroleum, although in one notable instance Silvestri found paraffine and other constituents of petroleum in the lava of Etna A comparison of the analyses of the gaseous emanations of volcanoes with those of gas and petroleum springs shows that the former consist mainly of carbonic acid and nitrogen, while the latter consist mainly of marsh-gas. Bitumens are not the product of the high temperatures and violent action of volcanoes, but of the slow and gentle changes at low temperatures due to metamorphic action upon strata buried at immense depths.

The extent of the Paleozoic formations of the Mississippi valley, and the general conformation of the bottom of the ancient seas, has been fully described by Professor James Hall,† He says: "In all the lower Silurian limestones we trace the outcrop to the west and northwest, from the base of the Appalachians in New York or in Canada to the Mississippi River, and thence still in the same northwesterly direction. . . . Instead of finding the lower Helderberg (Upper Silurian), strata in lines parallel with those of the preceding rocks, the relative direction of the main accumulation and the principal line of exposures is diagonally across the others. . . . The line of outcrop and accumulation has been from northeast to southwest, and they occur in great force far to the northeast in Gaspé, on the Gulf of St. Lawrence. . . . The greatest accumulation of materials in the period of the Hamilton, Portage, and Chemung groups (Lower and Middle Devonian), lies in the direction of the Appalachian chain. . . . In Gaspe there are 7,000 feet of strata, . . . while in Western New York the whole together would not exceed 3,000 feet. We have, therefore, the clearest evidence that the strata thin out in a westerly direction. . . . In considering the distribution of the masses of the formations which we have here described, we find that the greatest accumulations have been along the direction of the Appalachian chain. The material thus transported would be distributed precisely as in an ocean traversed by a current like our present Gulf Stream; and in the gradual motion of the waters during that period, to the west and southwest, the finer material would be spread out in gradually diminished quantities, till finally the deposit from that source must cease altogether. . . . I have long since shown that . . . the portion of the Appalachians known as the Green Mountain range is composed of altered sediments of Silurian age. . . . The evidences in regard to the White Mountains, to a great extent are of a newer age than those of the Green Mountains, or Devonian and Carboniferous. . . . The statements of Sir William Logan in regard to the great accumulation of strata in the peninsula of Gaspe, together with the observations of Professor Rogers in the Appalachians of Pennsylvania, lead to the inevitable conclusion that the sediments of this age must everywhere contribute largely to the matter forming the metamorphic portion of the Appalachian chain as well as to the non-metamorphic zone immediately on the west of it."

It is not necessary here to discuss the nature or origin of metamorphic action. It is sufficient for our purpose to know that from the Upper Silurian to the close of the Carboniferous period the currents of the primeval ocean were transporting sediments from northeast to southwest, sorting them into gravel, sand, and clay, forming gravel bars and great sand beds beneath the ripples, and clay banks in still waters, burying vast accumulations of sea weeds and sea animals far beneath the surface. The alteration due to the combined action of heat, steam, and pressure, that involved the formations of the Appalachian system, from Point Gaspe in Canada to Lookout Mountain in Tennessee, including the Carboniferous and earlier strata, distorting and folding them, converting the coal into anthracite and the clays into crystalline schists, along their eastern border, could not have ceased to act westward along an arbitrary line, but must have gradually died out farther and farther from the surface. The great beds of shale and limestone containing fucoids, animal remains, and even indigenous petroleum, must have been invaded by this heat action to a greater or less degree, and that "chronic evaporation" of Professor Lesley must have been the inevitable consequence.

Too little is known about petroleum at this time to enable any one to explain all the phenomena attending the occurrence of petroleum, upon any hypothesis; but it seems to me that the different varieties of petroleum, from Franklin dark oil near the surface to Bradford and Clarendon amber oil far beneath the surface, are the products of fractional distillation; and one of the strongest proofs of this hypothesis is found in the large content of paraffine in the Bradford oil under the enormous pressure to which it is subjected. So, too, the great pools of oil in southern Kentucky are without doubt distilled from the geode cavities beneath and concentrated in fissures of the rocks near the surface.

If this hypothesis, which embraces all of the facts that have thus far come within my knowledge, really represents the operations of nature, then we must seek the evidences of heat action at a depth far below the unaltered rocks in which the petroleum is now stored. We ought to expect to find the coal in its normal condition. We should not expect to find the carbonized remains of organisms in the rocks containing the petroleum. As the metamorphic action took place subsequent to the Carboniferous era, we should expect to find the porous sandstones of that formation in certain localities saturated with petroleum. Moreover, we should expect to find these Coal measure sandstones and conglomerates on the western border of the heated area, where the thinning out of the deposits brought down the Coal-measures nearer the Devonian shales and Silurian limestones, first saturated with petroleum, and then, through ages of repose, gradually cut down by erosion into the canons of Johnson County, Kentucky, and exhibiting all of the phenomena described by Professor Lesley.

The inadequacy of the scattered remains of plants in the Coal-measure sandstones as a source of the petroleum that saturates them is shown by the following calculation, which was made by Professor Lesley for another purpose: "Should the Mississippi send down one tree a minute for a century, with an average length of forty feet and a foot in diameter, and these be laid together side by side at the bottom of the sea in a single stratum, they would cover only a space of 200 acres. Were it possible, which it is not, to compress and crystallize these lignites into a stratum six feet thick, they might then constitute a coal bed covering twenty acres All the forests of the Mississippi valley could not furnish to the sea from their river spoils during a hundred thousand years one of the anthracite coal beds of Schuylkill County."*

According to M. Coquand, the petroleum of Wallachia is in the inferior Tertiary with mud volcanoes and rock salt; the "Flysch à Fucoids" is the horizon in Moldavia, corresponding to the formation in which it occurs in the Crimea, Transylvania, Galicia, Volterra of Tuscany, the Apennines, Sicily, and Algeria, being everywhere rich in fucoids. The conclusions reached by geologists regarding the occurrence of petroleum in Galicia show that the central core of the Carpathians consists of metamorphic rocks, on the flanks of which lie the members of the Cretaceous and Tertiary formations, consisting of limestones, sandstones, and shales. The latter are for the most part rich in organic matter both vegetable and animal, such as fossil fucoids and fish. In East Galicia and Bukowina heavy beds of black bituminous shales are particularly noticeable. These formations lie in folds, the petroleum, which belongs to the third class, occurring under the arches of anticlinals rather than in the troughs of synclinals.

The facts to be obtained regarding the occurrence of bitumen in Asia are very few. It appears to be generally concluded that the formation from which the petroleum in the neighborhood of the Caucasus arises is Tertiary; but so far as I can ascertain it issues rather from erratic beds of sand in superficial clays than from any well defined formation. Lartet appears to regard the bitumen of the Dead Sea as of volcanic origin. The petroleum of Java lies in the Tertiary beneath alluvium, which flanks the volcanic core of the island.

Granting that the petroleum of the Niagara limestone at Chicago is indigenous, the invasion of that limestone by steam under high pressure would cause the petroleum to accumulate in any rock lying above, porous or fissured sufficiently to receive it. The mingling of oils that produce asphaltum and those that contain paraffine, and the occurrence of paraffine in large masses in porous strata filled with the remains of fucoids and marine animals that flank the core of crystalline schists in Roumania and Galicia, offer the strongest support to this hypothesis. The fact that the eruptive rocks of Lake Superior and the metamorphic rocks farther east prevail to such an extent that that vast inland sea has been supposed to be the crater of an extinct volcanic lake lends the strongest support to a hypothesis that regards the vast accumulations of petroleum in Western Canada as due to invasion of strata on the borders of this heat center, in which the petroleum is indigenous, by a sufficiently elevated temperature to cause its distillation.

Mud volcanoes and hot springs, it appears to me, are properly regarded as the phenomena attending the gradual subsidence of metamorphic action in the crust of a cooling earth. The accompanying petroleum or maltha is but the accident of such phenomena when strata containing organic remains are still invaded at a great depth by a temperature sufficiently elevated to effect the distillation of their organic contents. Gas springs may own the same origin, or the gas may escape from deep seated reservoirs, the product of a distillation long since completed.

Solid bitumens of the fourth class occur in great variety.

The universal distribution of bituminous material in rocks was noticed in 1823 by the Hon. Geo. Knox. The occurrence of disseminated bitumen in metamorphic rocks, supposed to be Laurentian, at Nullaberg, in West Sweden, has been described; also in the lower Silurian of south Scotland; in trap near New Haven, Connecticut; and in northern New Jersey, all of which are manifestly the results of the action of heat upon the organic matter in stratified rocks. The occurrence of bituminous limestones in France and in the valley of the Rhone has been attributed almost unanimously by French geologists to the action of igneous or metamorphic agencies.

There remain the phenomena attending the occurrence of large veins of solid bitumen in Cuba, West Virginia, New Brunswick, and elsewhere, for which no adequate explanation has been proposed that does not regard them as the product of distillation from deep seated strata which has been projected into a fissure formed by the sudden rupture of the earth's crust. Dr. R. C. Taylor examined the vein which occurs in metamorphic rocks near Havana, and concluded that "it was evidently originally an irregular open fissure, terminating upward in a wedge-like form, having various branches, all of which have been subsequently filled with carbonaceous matter, as if injected from below, and that not by slow degrees, but suddenly and at once." No hint is given by Dr. Taylor respecting the age of these rocks, as at the time he wrote (1837) the relation between metamorphic and sedimentary rocks had not been established. There is little doubt, however, that the veins in New Brunswick and in West Virginia originated at nearly the same time and subsequently to the Carboniferous era. It is certain that subsequent to that era a great convulsion caused an upheaval that in collapse produced the White Oak anticlinal in West Virginia, very near the southern end of which occurs the vein of Grahamite, cutting the horizontal sandstones of the coal measures vertically. Those who mined the vein declare that the material must have welled up from beneath into the fissure the instant it was formed. Numerous fragments of the wall rock were found embedded in the asphaltum 12 to 15 feet below the cavities from which they fell, with all of their edges and angles sharp and exactly fitting each other. Curious curved lines, resembling those produced when a stone is dropped into mortar, are found on these horses, suggesting the probability that the horses fell into a plastic mass that rolled upon them, producing lines of unequal pressure and adhesion that remain after the asphaltum has cleaved from the horses or inclosing walls. Moreover, neither the walls of porous sandstone, nor the horses, have absorbed the bitumen to the thickness of paper. The significance of these facts was more forcibly impressed upon my mind when I found among a suit of specimens from the albertite vein of New Brunswick a piece of the inclosing shale, marked with the mineral in forms almost identical with those observed on the sandstone horses in West Virginia.*

In 1869 I made the origin of albertite and allied substances the subject of a paper in which I compared the observations made in New Brunswick and West Virginia with my own observations of a vein on the coast of California, which is exposed west of Santa Barbara, and stands vertical, cutting the Pliocene and recent sands. With this vein are associated lenticular masses extending horizontally, from which a sort of talus projects vertically into the sands beneath.† Similar deposits are described by M. Coquand as occurring in Albania. He mentions in connection with the bituminous strata, solfataras and mud volcanoes both active and extinct, with which was associated more or less fluid maltha, which was at first very liquid, but soon became sirupy and was finally added to the accumulations of the bituminous cone. From his statement it appears that solid bitumen occurs in great abundance, filling variously formed cavities, which in no case penetrates the roof above the mass, "but was evidently injected from below." Here the maltha accompanies the water of springs from deep seated strata often in close proximity to active or extinct volcanic action of the mild forms observed as solfataras, mud vulcanoes, or salses. The great similarity in the occurrence of intruded Tertiary bitumens in Albania and California is very remarkable.

It should be borne in mind that while this subject is one of speculation, pure and simple, it is a subject that has its valuable consideration outside the domain of scientific inquiry or curiosity, as affecting the sources and duration of supplies of petroleum, its profitable development, and commercial permanence. If petroleum is the product of a purely chemical process, we should not expect to find Paleozoic petroleums of a composition corresponding with the simple animal and vegetable organisms that flourished at that period, and Tertiary petroleums containing nitrogen, unstable and corresponding with the decomposition products of more highly organized beings; but we should expect to find a general uniformity in the character of the substance, wherever found, all over the earth. The advocates of the chemical theory affirm that they provide for a process the conditions of which are perpetually renewed. It is thus continuous and at present active. On the contrary, if petroleum is the product of metamorphism, its generation is coexistent only with that of metamorphic action, an action which we have no reason to believe has been prevalent on a large scale during the recent period. If we accept this hypothesis, the generation of petroleum must be considered as practically ended.

* Abstract of Chapter V. of the Monograph on Petroleum, prepared for the Tenth Census of the United States.

† Nat. Hist. N. Y. Paleontology, iii., 45-60.

* A Manual of Coal and its Topography, p. 49.

* Very carefully drawn illustrations of these stones have been introduced in the original monograph.

† This Journal, II., xlviii., 362.

RED SUNSETS.‡

THE equatorial diameter of the earth is 7,901 miles and the circumference is 24,825, and as she revolves once on her axis in twenty-four hours, a place on the equator moves through 1,034 miles in an hour; but at any depth beneath the surface the velocity is less in proportion to that depth; in like manner, if we look on the atmosphere as part and parcel of the earth, at a certain height the velocity is greater in proportion to that height.

The whole world has been greatly interested during the last seven or eight months with the beautiful phenomena of colored suns and brilliant sunsets; and the liveliest interest has been exhibited as to their origin. Lockyer was the first, I believe, to point out the fact of the phenomenon of colored suns appearing first in the east and then gradually shifting to the west. He traces them to Panama, and speaks of them as having been seen on a north-south line; but it strikes me that after leaving Panama the phenomenon passed still further westward, was seen on September 3, 4,000 miles west of Panama, and at Honolulu on September 5, and struck India and Ceylon on the 8th, thus performing more than a complete circuit of the globe; moreover, I am of opinion that it may be traced still further westward, where it was seen in lat. 24° 6′ N., long. 140° 29′ W., by Capt. Penhallow, of the bark Hope, on September 25, having then performed 2¾ revolutions of the globe.

All the information that I have collected, and from which I have compiled the following tables, has been obtained from *Nature.* The time column has been deduced from the time and date of the phenomenon appearing at the different stations reduced to Krakatoa time; in some instances great difficulty has been experienced, especially in reference to the time at Maranham in Brazil, and at Trinidad, and it has been concluded that at those stations the times are late, because it was seen at Panama before the time given at them, which we suppose to be an error. Likewise in the case of the Gold Coast, in one place the date given is August 30, and in another September 1, but from the general result it appeared to have reached that locality about midnight, August 30-31.

The tables, I trust, are sufficiently clear; the first column of miles represents the mean diurnal velocity that the cloud traveled at between Krakatoa and the different localities *en route;* and in the subsequent columns are given the same from each station in rotation. Of course it will be understood that a small error of an hour or two in the time at the

‡ A paper read by Alexander Ringwood at an ordinary meeting of the Canterbury Philosophical Institute, New Zealand, May 1, 1884.—*Nature.*

stations comparatively close to the eruption would make a large difference where we show the *diurnal* velocity; and as I have had only a week's notice to prepare this paper, I trust that any errors that may be hereafter found will be treated with that consideration.

TABLE I.—*Showing the Mean Diurnal Velocity in English Miles of the Phenomena of Colored Suns and Brilliant Sunsets in the Northern Hemisphere.*

	Time from Java to	Java.	Seychelles.	E. Coast of Africa.	Gold Coast.	Maranham.	Trinidad.	Panama.	4000 miles W. of Panama.	Honolulu.	India.
	h.										
Seychelles	45	1802									
E. Coast of Africa	58	1817	1873								
	days										
Gold Coast	4	1846	1969	1972							
Maranham	5	2020	1950	1896	1904						
Trinidad	5½	1968	2080	2040	1940	2176					
Panama	6¼	2059	2040	2176	2324	1930	1986				
4000 miles W. of Panama	8¾	2061	2424	2310	2400	2370	2338	2000			
Honolulu	9½	1900	2084	2080	2036	1909	1748	1716	1122		
India	12¼	2162	2278	2192	2328	2212	2084	2200	2310	2244	
Lat. 24° N., long. 140° 30′ W.	29½	2132	2246	2306	2268	2165	2400	2170	2460	2316	2192
Arithmetical means		1976	2105	2091	2185	2127	2111	2082	1964	2280	2192
True mean		2095									

Arithmetical mean for Northern Hemisphere, 2,105 miles per day.

The true mean of the first column, viz., that under the head of Java, is obtained by adding the distance between Krakatoa and each separate station together, and dividing the aggregate by the gross total number of days. The way by which the distance between any two stations is derived is by multiplying the difference in degrees of longitude by the value of a degree in English miles for the mean latitude of the two places. It must be remembered that between India and the last named locality on the list the dust cloud is supposed to have performed over a revolution and a half of the earth.

I place great confidence in the result obtained from the observations deduced from India, because there scores are of trained meteorological observers, whose duty it is to immediately report any phenomena that may take place, and such as that concerning which I speak could not have escaped their immediate notice; so we may conclude that the hour of its arrival there is very accurately determined, which gives a mean daily velocity of 2,162 miles; and taking the velocity from its journey and a half round the world, from India to lat. 24° N., lon. 140½° W., we find it to be 2,192 miles per day, or 30 miles only in excess of the other computation. But if we take the whole journey from Krakatoa to that locality, about 2¾ revolutions round the globe, we find the mean to be 30 miles less than the first, or 2,132 miles, and that will be accounted for through the diminished value of the degree in longitude at the mean latitude between Java and lat. 24° N., long. 140½° W.

The mean diurnal velocities obtained from the intermediate stations, between Java and India, agree very closely; when we consider that at those several places the phenomenon was wholly unexpected, and thus in most instances the dates and times given appear to be somewhat late, it is quite possible and natural that it escaped notice at least once; in India, however, we may conclude that they were on the alert, and consequently the mean velocity deduced from that place ought to bear great weight. There is another thing that ought not to be lost sight of, viz., that without this list of stations, more than encircling the globe, one might suppose that the *cloud* after leaving Krakatoa stretched away westward, and as I gather from Lockyer's paper by his *north-south* line, to have extended to the north and south, forming a letter V with the apex at the Straits of Sunda. Now Lockyer tracks it to Panama, to which place we see it to have had a diurnal velocity of 2,059 miles, and from Panama to India I made it 2,200 miles per day, which makes me believe that the cloud was performing a spiral path northward round the globe.

Before proceeding I will now turn to the observations in the Southern Hemisphere, in order to see whether the same has taken place there. This table has been prepared in like manner to the former, viz., the dates and times are reduced to that of Krakatoa, and the distances in English miles obtained from the difference in degrees of longitude reduced to the value of the mean latitude of the two places.

TABLE II.—*Showing the Mean Diurnal Velocity in English Miles of the Phenomena of Colored Suns and Brilliant Sunsets in the Southern Hemisphere.*

	Time from Java to	Java.	Mauritius.	Adelaide.	Cape of Good Hope.
	h.				
Mauritius	44	1680			
	days.				
Adelaide	2¼	2041	1980		
Cape of Good Hope	24	2082	2047	2010	
Christchurch	29¼	2134	1900	2120	2070
Arithmetical means		1984	2005	2065	2070
True mean		2100			

Arithmetical mean for Southern Hemisphere, 2,031 miles per day.

The marked similarity between these two tables is most striking, and as in the first table the greatest discrepancy are found between Krakatoa and Mauritius, where the data are reckoned in so many hours, in which case an hour or two makes a material difference in the diurnal velocity. At present I cannot find any station reporting the phenomenon between Mauritius and Adelaide, but we may conclude that after it passed Mauritius it crossed Africa, the South Atlantic, and South America, whence we may expect to hear of it, as there are many competent observers in that part of the world; it then traversed the great South Pacific Ocean and North Australia, and after performing another such journey round the world, but in a higher latitude, was seen at Adelaide in South Australia about September 17. I conclude, as Mr. Todd, the Government Astronomer, there says in his report to *Nature*, "that it was visible during the last fortnight of September." We next hear of it at the Cape of Good Hope on September 20. It again crossed the South Atlantic and South America about the latitude of Buenos Ayres, and a third time traversed the South Pacific, striking the coast of New Zealand on September 25, the date of my first seeing it; on which occasion the western sky at sunset presented all the colors seen in the pearl shell. Since then the western and eastern skies have presented those beautiful crimson tints that have delighted the world, and on many occasions I have seen it almost in the zenith two hours after sunset. During some evenings it has quite illuminated the western face of buildings with a bright glare as from a fire, while on others it has been very faint and sometimes not discernible; giving to my mind the idea of its not being a continuous band, but a series of dust-clouds with clear spaces between.

From an investigation of the two tables, it will be seen that the mean diurnal velocity in the Northern Hemisphere was, during the first revolution, about 2,162 miles, and during the second it increased to 2,192, or 30 miles per diem extra. And the same increased velocity is observed in the Southern Hemisphere, where we find the approximate velocity during the first two revolutions, viz., on its reaching Adelaide, to be 2,041, whereas during the next revolution from Adelaide round to New Zealand it was 2,120 miles, or an increase of 80 miles per day. It will be further noticed that in the Northern Hemisphere the time occupied in its first revolution was about eleven days, and the same rate is observed during the next revolution and three-quarters, or, in other words, within the tropics it encircled the world in eleven days. It is the same within the southern tropics, where it took 21¼ days to reach Adelaide in its second revolution, but it performed the next revolution in about 9½ days, reaching New Zealand in 29¼ days after the eruption. Thus it performed 2¾ revolutions in the Northern Hemisphere in 29⅔ days, and in the Southern Hemisphere it performed 2⅞ revolutions in 29¼ days, showing that the initial velocity at starting has only very slightly fallen off in even latitude 45° S. So in the following discussion I will adopt a mean diurnal velocity for the dust cloud of 2,088 miles, or 87 miles per hour, to the westward.

As I showed at the beginning that, if the atmosphere be considered as part and parcel of the earth, a particle of it at a certain height will cover a greater distance in a certain time than that part of the earth immediately beneath would, so if we know the rate per hour that a certain thing *apparently* moves to the westward, or seems to lag behind the diurnal revolution, we can ascertain the height. We know that it lags behind at the rate of 2,088 miles per day, which added to the circumference of the world gives a circle of 26,908 miles, and this divided by 3·1416 gives a diameter of 8,566 miles, or 664 miles greater than that of the earth, or a height of 332 miles above the surface. Or, putting it this way, we may assume that at the latitude of Krakatoa the earth has an hourly velocity of 1,034 miles, and that any matter ejected thence into the upper regions of the atmosphere would retain the same rotary velocity as it had before, viz., 1,034 per hour to the eastward; but we have material under our observation which cannot keep its zenithal position at starting, by 87 miles per hour, showing it to be at an elevation of 332 miles.

Now the spectroscope tells us that the red color is produced through dust of almost ultra-microscopic fineness, and in some specimens of this dust that have already fallen the microscope shows the existence of *salt* crystals, which fact in itself almost proves it to be of volcanic origin, and not meteoric or cosmic dust. Now Prof. Helmholtz states that "the reflecting medium, whatever it was, over Berlin on the last three nights of November was about 40 miles above the earth;" and if we work on this data we have a circle whose diameter is 80 miles greater than that of the earth, or a circle of 7,981 miles, which multiplied by 3·1416 gives a circumference of 25,073, or 248 miles more than that of the earth, which, divided by 24, shows an excess of about 10⅓ miles per hour above the surface velocity of rotation. But we want to account for an excess of 87 miles per hour; so if we accept Prof. Helmholtz's statement we must only suppose that at the altitude of 40 miles there is an easterly current, or one moving to the westward, of 77 miles an hour; for, assuming as we do from the foregoing tables and calculations that the earth rolls from under the cloud at the rate of 87 miles per hour, unless we admit of an easterly current we cannot stop short of that enormous height of 332 miles unless we suppose that the power of gravitation has only a feeble hold on those most minute dust particles at the altitude of 40 miles, where the atmosphere has not the many thousandth part of the density it has on the surface of the globe.

Mr. W. H. Preece writes stating his opinion that the mass of matter ejected retained the same electric sign as that of the earth, and as long as that was the case the repulsion force would be sufficient to keep the matter afloat; and in reference to that theory Mr. Crookes writes to state that with a rarefaction of one-millionth of the atmosphere, two pieces of electrified gold leaf repelled each other at a considerable angle for thirteen months, and goes on to state that that rarefaction is attained at an altitude of 62 miles, and that the air there is a perfect non-conductor of statical electricity, without interfering with the mutual repulsion of similarly electrified particles; and when we bear in mind that the particles of minute dust are many thousands of times smaller and lighter than the gold leaves operated upon, there is every reason to believe that electrified dust, once projected 50 or 60 miles high, might remain there many years.

Before proceeding further I must draw your attention to the fact that at the time of the great eruption, and during September, the mean temperature at Batavia, and throughout Java generally, is at its maximum; consequently we may conclude that the equatorial belt of calms and uprushing air that encircle the globe was lying over that district at the time. This uprush is caused through the heated atmosphere rising, and the two trade winds, the northeast and southeast, feed it. When this heated air has attained its proper altitude, it flows off to the north and south, but the rotation of the earth causes it to flow toward the northeast in the Northern Hemisphere, and to the southeast in the Southern Hemisphere, and these winds are called by some the return trades, and by others the southwest and northwest upper currents respectively, and are of great altitude, probably ranging up to 50,000 feet.

Well, the most bulky masses cast upward by the eruption of Krakatoa would immediately fall, and the less bulky would fall later according to their size, but the great portion of the dust and ash would be caught, on its downward course, in those upper currents just alluded to, and be carried by them to the northeast and southeast. Such we find to be the fact, for the ship *Meda*, when to the westward of Cape Northwest, Australia, or about 1,050 miles southeast of Krakatoa, experienced a fall of dust like fuller's earth, which covered the vessel, on the night of August 30–31, and Capt. Tierney, of the brig *Hazard*, on September 1, near New Ireland, a distance of 3,850 miles due east of Krakatoa, saw the colored suns, which was no doubt due to the presence of dust in the atmosphere, drifted eastward with the upper current.

Now, turning to the northeast quarter, or the direction in which the southwest upper current of the Northern Hemisphere proceeds, we find that in Japan during August 29, 30, and 31, the sun was of a copper color, and had no brightness in it; at Yokohama, Mr. Hamilton states that on the 29th and 30th the sun was of a blood-red color, and appeared to be obscured. This is at a distance of about 3,000 miles from Krakatoa, which gives a velocity of the upper current, or return trade wind, of about 62 miles per hour; this is not excessive, as I have often measured the velocity of the northwest upper current at Adelaide as over 80 miles per hour.

You may remember that I did not continue the tracking of the dust cloud, from that position assigned to it by Capt. Penhallow, in lat. 24° N., long. 140½° W., on September 25, because the European and American reports are so peculiar. It was apparently seen in England *before* the rest of Europe, viz., on November 4 and 9, in California on the 20th, San Francisco on the 23d, Italy on the 25th, New York on the 27th, and at Berlin on the 28th; so you see that the geographical arrangement is rather mixed in reference to the order of dates. This may be accounted for by the fact that there was a very severe volcanic eruption in the Alaska Group and Peninsula in October, I think; it was very intense, and quite capable of ejecting a dust cloud that would envelop the polar and temperate regions of the Northern Hamisphere; of course it was not nearly so terrific as that of Krakatoa. So you will see that we must be careful before we assert that the brilliant sunsets of Europe are of Krakatoan origin.

The phenomena of colored suns and brilliant sunsets, I may tell you, have been seen before, both in Europe and America, in connection with Vesuvian and Iceland outbursts; Mr. Somerville, the famous geographer, gives an instance of it which had been seen in Norway, and traced its origin to a severe eruption in Iceland. And H. C. Russell, B.A., F.R.A.S., F.R.Met.S., Government Astronomer, Sydney, in his book on the climate of New South Wales, pages 187, 188, gives some most interesting instances of historical accounts of darkened and colored suns. I will quote them in their chronological order:

"'At certain times the sun appears to be not of his wonted brightness, as it happened to be for a whole year when Cæsar was murdered, when it was so darkened that it could not ripen the fruits of the earth.'—Virgil, *Georg.*, lib. i., etc.

"In 1090 there was a darkening of the sun for three hours.

"In 1106, beginning of February, there was obscuration of the sun.

"In 1208 there was a darkening of the sun for six hours.

"In 1547, August 24 to 28, the sun was reddish, and so dark that several stars were visible at noonday.

"In 1706, May 12, about ten o'clock in the morning, it became so dark that bats commenced flying, and persons were obliged to light candles.

"In 1777, June 17, about noon, Messier states that he perceived an immense number of black globules pass over the sun's disk.

"In 1783 there was a *dry fog*, and many attributed it to volcanic action; and it is well known that in February that year fearful earthquakes in Calabria took place, followed by a long list of volcanic eruptions in other parts of the world.

"In 1831 was an extraordinary *dry fog*, which excited public attention throughout the world. It appeared on the—

Coast of Africa	August 3
At Odessa	" 9
In South France	" 10
Paris	" 10
New York	" 15
Canton, China	" end of.

This fog was so thick that it was possible to observe the sun all day with the naked eye, and without a dark glass, and in some places the sun could not be seen till it was 15° or 20° high. At Algiers, United States, and Canton the sun's disk appeared of an azure blue or of a greenish color. Where the fog was dense, the smallest print could be read even at midnight.

"In 1873, of the *dry fog* which came on suddenly in June, it is recorded that it extended from the northern coast of Africa, over France to Sweden, and over great part of North America, and lasted more than a month. Travelers found it on the summit of the Alps. Abundant rains in June and July and most violent winds did not dissipate it; and in some places it was so dense that the sun could not be seen until it had attained an altitude of 12°, and throughout the daytime it was red, and so dull that it might be looked at with the naked eye. The fog diffused a disagreeable odor, and the humidity ranged from 57 to 68, while in ordinary fog it is 100. It had a phosphorescent appearance, and the light at midnight was compared to that of full moon."

Here was exhibited a diagram, drawn correctly to a scale of fifty miles to one inch, showing the arc (15°) of a circle whose radius was 6 feet 7 inches, or a diameter or 13 feet 2 inches. The Himalayas were shown in their correct proportion, so was the smoke from Cotopaxi, estimated by Whymper while on Chimborazo at 40 000 feet; he saw at 5.45 a.m. of July 30, 1880, a dense column of smoke shot up straight into the atmosphere with prodigious velocity, which in less than one minute had risen 20,000 feet above the crater, giving the total height of 40,000 feet above sea-level. The dust, he goes on to state, fell on Chimborazo after six hours, and he estimated that each particle did not weigh $\frac{1}{12000}$ part of a grain, and the finest were still lighter.

Some people (and very rightly too) express wonder and unbelief at the possibility of *dust* being capable of having been shot up to such a height as that ascribed to it, as to cause the red sunsets—but here I have quoted the fact of such as seen by a man of known repute; the dust and ashes *were shot up* to that great height, and not only that, but as the dust cloud came between Mr. Whymper and the sun, he saw the phenomenon of the colored suns. The same may be seen during any very heavy dust storm anywhere, when the cloud is between the observer and the sun.

In this description given by Whymper, we have a good illustration of the tremendous force Nature uses in these convulsions; a force that could throw the finest dust to a *height* of 20,000 feet is almost inconceivable to the human mind, and in that phenomenon we have, I may say, only an everyday occurrence, when compared with that giant eruption of Krakatoa. Let us draw a comparison. At the destruction of Pompeii, situated at the *foot* of Vesuvius, the city was enveloped with darkness from the density of the dust and ash cloud that enshrouded it, and that ultimately

buried it; but now contemplate the tremendous power that ejected from a mountain a sufficiency of dust and ash to envelop a city in total darkness for thirty-six hours, *eighty miles distant*. On that diagram I have sketched an imaginary picture of the eruption, and eighty miles distant is represented by a little over an inch and a half, where you see the letter B, showing to your mind the relative distance of Batavia from Krakatoa. You can form in your imagination some idea of the great height that the dust cloud ascended; to my mind twice forty would not be too great. Then again we have the ship *Charles Bal*, when *thirty miles distant*, was enveloped at noon day in pitch darkness through the mud-fall. Furthermore, as Lockyer says, the sound, the least part of the affair, was heard over an area of 4,000 miles in diameter, viz., in Ceylon to the northwest, at Saigon to the north, and throughout North Australia to the southeast. In the last quarter the reports were at intervals of fifteen minutes, and sounded like ship-guns, but as the hearers were from 150 to 200 miles from the coast, such cause could not be assigned. All that can be said is that it is beyond the human mind to conceive of such gigantic forces, and therefore absurd to throw doubt on the result; by which I mean that if the laws of refraction show that the substance, whatever it may be, that causes the red glow is at an altitude of forty or sixty miles, it is ridiculous to doubt that result, when we cannot conceive the magnitude of the power that operated.

It was not only one eruption that took place, but several, during the 26th, the following night, and up to 11.15 a.m. of the 27th, about which time the grand finale is supposed to have taken place. These eruptions followed each other in rapid succession, and are thought to have been caused by the rapid conversion into steam of vast quantities of water that found admittance into the bowels of the earth. Later on the influx of water was too much, and the result was that a tremendous power was generated, so much so as to cause the north part of the island to be blown away, and fall eight miles to the north, forming what is now called Steers Island. This was followed by a still greater eruption, when it is thought that the northeast portion was blown clean away, passing over Long Island, and fell at a distance of seven miles, forming what is now known as Calmeyer Island. These suppositions are almost proved to be facts, from the Marine Survey of the Straits just concluded, from which it will be seen that the bottom surrounding these new islands has not risen, which would most naturally have been the case had they been caused by upheaval, but if anything the bottom shows a slightly increased depth in the direction of the great pit that now occupies the position that the peak of Krakatoa did the day before. These incidents are cited to show you the awful nature and magnitude of the forces brought into play, as you can the more readily satisfy your minds as to the great height the dust and ash were thrown to.

As I said before, this dust cloud may probably be denser in some places than others, owing that fact to the relative period of time that elapsed between each eruption; where it is dense we may assume that they followed each other rapidly, and where it is less dense the interval of time was greater. For you must remember that it was shown to you that the cloud apparently moves to the westward, or that the earth moves from beneath the cloud, at the rate of 87 miles per hour, so that during each hour of the eruption there was a long streak of smoke and dust being formed. These densest parts were no doubt the cause of the colored suns, and as some observers state, "the sun appeared to shine with diminished strength," others "that it was rayless and giving no heat," so we may look upon that dust cloud as playing the part of a great screen, shutting off some of the heat of the sun from us. In these southern latitudes we have experienced those brilliant sunsets for over seven months, and I have no hesitation in expressing my opinion that the remarkably cool and wet summer just passed in New Zealand was due to that great dust cloud shutting off the sun's heat in a great degree. And I see from the Adelaide report that the mean temperature there during January was over 4½ degrees cooler than the average of the previous twenty-five years, and on only one occasion during that period was it so low, viz., in 1869. At Melbourne also the weather was more like winter than summer, whereas in North and Central Australia, or I may say down to lat. 30° on that continent, the weather was fine, clear, and hot, without rain, giving me the idea that the sun had less power than usual; consequently the northwest monsoon was very feeble, not penetrating far inland, the result being that the interior of Australia has undergone one of the most disastrous droughts on record. But now that, as we may suppose, the equatorial regions of the atmosphere have parted with the greater part of their dust, if not all, the sun has regained his usual power, and the northwest monsoon its usual strength, penetrating the heart of Australia with refreshing rains and thunderstorms. So we have here an instance of a most terrific phenomenon that not only brought death and destruction to thousands at the time, but that indirectly caused the death of thousands and thousands of cattle and sheep through drought, and it would be most interesting and instructive to learn whether or not such consequences were experienced in other parts of the Southern Hemisphere at least.

It would be beyond the province of this paper, and in fact too late to-night, to give a history of the tidal and atmospheric waves that resulted from this eruption, but I will state two facts to finally clinch your mind of its magnitude. When the earth opened her mouth and swallowed that vast quantity of water, the down-rush that accompanied the closing-in of the surrounding crust was so much as to produce a tidal wave that passed and repassed twice, I believe, round the globe. The other fact is, that the tremendous explosion that accompanied the final eruption produced such a vacuum as to cause atmospheric waves to start, and which traversed and retraversed the earth to the antipodes of Krakatoa no less than four times.

Some astronomers have thought that the whole phenomenon may be accounted for by supposing the earth to be passing through a dense meteoric track. To my mind, however, the greatest difficulties brought to bear against the volcanic theory are child's play when compared with the possibility of about 10,000,000,000 to one of a meteoric track so formed as to have its path, either at aphelion or perihelion, so remarkably coincident with that of the earth as to keep company with her for seven or eight months. Besides, were it either meteoric or cosmic dust, it would be seen all over the earth at the same time, and would be visible all night.

No; the only extra-terrestrial argument that would bear any investigation is that of its belonging to the phenomenon of the zodiacal light, which argument, I believe, was adopted at first by my friend Charles Todd of Adelaide; but, as time goes on and more information is gathered, the volcanic theory, I believe, will be finally adopted.

THE TEREDO AND ITS WORK.

THE ship worm—*Teredo navalis*—is a mollusk belonging to the tubiferous bivalves, and has been from time immemorial, and in all quarters of the globe, the subject of comment on account of its ravages in timber exposed to its attack. There are twenty-four species of the teredo, but the ship worm is the best known of these, although much is yet to be made known concerning it before the information upon the subject can be said to be even approximately complete. Along the Gulf Coast of the United States the worm has been carefully studied by the builders of railroads, and the students have been rewarded more abundantly in that district than those who have examined the subject elsewhere. The results of some of these studies are here presented, and in these results some statements will be found which will prove new and of interest to the scientific world.

"If I had a boring instrument of this sort I would make a fortune," said a recent observer of the teredo. He spoke truly, for such an instrument, should it exist in mechanics, would revolutionize the builder's art. Yet an almost similar one is in daily use under a patent from the government. The instrument is the flexible shaft boring machine, which many of the readers of this paper have doubtless seen. It

is a spiral of steel having a steel bit at its extremity, revolving with a pulley shaft. The spiral is protected by being run through a rubber hose, so that only the auger itself visibly revolves, and the machine can be handled without danger. The auger bit can be turned in any direction, and as it is revolving at a high rate of speed, can be easily pushed through timber. The first impression the working of this mechanism makes upon the uninstructed observer is lasting. The *Teredo navalis* is a natural reproduction of this instrument, and someting more. Its long and flexible body terminates in cutting shells or bits, and is inclosed, for the sake of its protection, in a hose-like shell, which reaches from the inferior extremity to within a very short distance of what is known as the head. At that point the muscles come into play and work the cutters or bit edges, and so drive into the timber, cutting as smooth and as round a hole as any boring machine yet invented. Like the flexible auger, it can turn itself in any direction, but it has this advantage: it can change its course at any point, whereas the auger, once entered, pushes straight ahead until the hole is bored the requisite depth. An auger that could be guided at an angle from its course after penetrating the wood would be indeed the most wonderful boring machine in the world. Such a boring machine is the teredo.

The teredo first appears in the egg, which is round like a mustard seed, and so small that a hundred of them will lie in a circle the size of such a seed. They come from a whitish looking mass just below the stomach of the adult teredo, about one-fourth the distance from the head to the tail, and are in number from one to three millions. These eggs are laid at the beginning of the warm season in the spring, and are deposited from time to time until cold weather sets in. Naturally the worm is most destructive during this warm season. The eggs batch in the water and give out minute worms about the twenty-fifth of an inch long and so small in diameter as to be invisible to the inexperienced observer. They swim about for a day or so in the water, apparently enjoying their brief time of adolescence, and then search for timber. They enter this by boring or cutting with the shells or cutters with which each is provided, and the entrance they make is so small that it can scarcely be seen, especially in weather-stained wood. The size of the hole is about that of the period at the end of this sentence.

The worm grows at the rate of about two inches per month under favorable circumstances, and digs a hole to accommodate its increasing size. The length of the hole is therefore a guide to the length of the teredo; for it attaches its

smaller end to the entrance of its burrow and pushes forward with the growth of its body. As it progresses, it deposits a coating of lime upon the sides of its cell, the deposit growing thinner as the animal advances, being quite thick at the entrance and merely a film near the head, where is collected a whitish, watery fluid, which probably contains the lime secreted for making the lining of the cell, and perhaps also for repairing the wear of the cutters.

The worm continues it progress for one or one and a half years, and propagates and dies. It is said by naturalists to reach the length of 10 or 12 inches, but they grow much larger than this in the Gulf coast latitude. The largest one authentically observed was 23 inches long, and five-eighths of an inch thick at the large end. Mr. J. W. Putnam, of New Orleans, from whom much interesting data upon this subject has been obtained, says he found a hole in which a teredo had died, which was three feet long and three-fourths of an inch in diameter at the large end. When grown, the teredo is seen to be a mucilaginous worm, attenuated in shape, extremely delicate to the touch, and tapering to a very small point. The anterior or large end has two bifurcations, provided with horny styles, which close up against each other like shells. These cutters are attached to a pair of strong muscles which operate them like forceps or scrapers, the edges of the shells tearing away little chips or fibers of the wood. The continued scraping makes the walls of the cell regular, and time, with the action of water, polishes them smooth. The bore of the teredo when examined is seen to be perfectly round and the surface free of indentations. It is also generally straight, as the inclination of the worm is in the line of the grain of the wood, and is diverted only when the course will project it into the tunnel of some other borer, or when the path leads through hard knots or twists in the wood. The accompanying engraving of the worm is about two-thirds of the present size of the preserved specimen from which it was made. The latter was kindly furnished the *Lumberman* by Mr. J. W. Putnam, of the creosote works at West Pascagoula, Miss., and may be seen at any time in this office. It was taken from timber which had been in an arm of the Gulf of Mexico one year, and was 12 inches long when secured, February 21, 1878.

It is remarkable with what accuracy the teredo avoids the burrow of its neighbor. There may be hundreds of worms living in the same cubic foot of timber, but they never, even by accident, cut across or into the cavities. It is not known whether in this they are guided by the touch or the hearing, probably both. Coming in contact, during its boring, with wood having obnoxious qualities, the worm avoids it by going around, or it will back down a third of its length and begin a branch tunnel, previously building a calcareous dam across the abandoned portion of its cell. It will cut within the least possible distance of its fellows, or within a hair's width of the outside of the timber, without breaking the division wall.

Continuing the description of the teredo, however, one will find, just at the base of the cutters, the esophagus or orifice leading into the stomach, in which can be traced the fine sawdust and chips, showing that the worm feeds upon such matter. This is more likely to be food for the worm than the debris of stone which the shell fish (*Lithophagi*), of the same group as the teredo, have to swallow in the course of their cutting operations. An intestinal canal about the sixteenth of an inch in diameter in adults, and continually growing smaller, extends from the stomach to the inferior extremity. The stomach itself is a dark looking sac, nearly of the diameter of the teredo and situated a short distance from the "head." Whether the worm has even a rudimentary brain or spinal cord, and consequently a real thinking, commanding brain, is not certainly known. It is almost transparent, and its interior arrangements can be plainly seen when it is suspended in glycerine or alcohol, but outside of the viscera above mentioned, there is nothing of importance visible. The smaller end of the teredo is attached to the shell lining by a membrane in the shape of a sleeve which closes the entrance hole and prevents water from coming into the cell. This sleeve is provided with two long appendages, file like, which it protrudes, by muscular action, out of the aperture. This is partly an instrument to aid in the removal of the rough and unyielding debris of the wood cut by the worm, and partly a weapon of defense against enemies. Without some such protection a rival teredo or some parasite could enter the tunnel and devour the inmate alive.

The teredo having lived its span, given birth to millions of young ones, closes the outer aperture with a coating of of lime, entombs itself, and dies. Often, however, death comes before the allotted time, for so many worms will enter a piece of timber as to eat it up. The whole community, having no future means of subsistence, dies of starvation. Logs have been found cut all to pieces and filled with half grown worms all dead. Sudden death also comes sometimes from floods of muddy fresh water. When the Mississippi River broke through Bonnet Carre crevass, muddy river water flowed through Lake Pontchartrain and Lake Borgne into Mississippi Sound, driving out the salt water as far east as Pass Christian, and the teredoes were killed in great quantities. It seems the worm withstands clear fresh water very well, for at Brisbane, Australia, it is forced to survive the annually recurring exposure to fresh water, lasting from two to three months.

Drying in their cells, the sea water soon penetrates the lime blockades and dissolves the glutinous mass. The shell lining washes out in a few months, and a smooth and gracefully curved hole remains, a monument of the destructive work of the *Teredo navalis*.

As previously intimated, the teredo may be found in all quarters of the globe, but its ravages are greatest in the warm waters of equatorial seas. This is accounted for by the fact that the summer season is the time of activity for these worms, and the season lasts longer in the southern waters. The teredo has appeared with destructive effect in colder climes, however. It is recorded that in 1731 and 1732 it suddenly appeared in prodigious numbers in Holland, and threatened the country with inundation by devouring the piling of the dikes. The worm bores in any kind of timber, in soft as well as hard, except that of trees of evergreen growth like the palmetto palm. Its work is very rapid. Boats and barges have been sunk in a few days by the penetration of the shells, and solid piles, 12 or 15 inches in diameter, have been cut so completely away as to break of their own weight and fall down within six months of the time they were placed in the water. A piece of timber which is completely worm eaten will preserve its outer surface perfect up to the moment it falls. Close examination of such a sample of wood shows that in the outer surface are innumerable holes about the size of a pin. These are the entrance holes of the teredo; break the wood, and it is found honeycombed in cells of from a half inch to 20 or more inches in length, as indicated in the engraving, which was made from a section of what appears to have been a five inch post or possibly a telegraph pole. In some of the cells will be found the worms, in others nothing but the cutting shells, lying at the large end of the cell, and in others nothing at all to show how the holes were bored. The interior of a teredo eaten pile looks very much like a rough sponge.

Naturally, where the damage possible to be inflicted by the teredo is so great, every art has from time to time been employed in attempts to counteract the effects. The old method of coppering the vessel's bottom has been long in vogue, and is, of course, successful. It was found impracticable, that is, too costly, to use this method of preserving piling and wharves. It was thought that the timber could be poisoned, and many rank poisons, such as arsenic, strychnine, corrosive sublimate, etc., were tried, but the teredo seemed to thrive as well upon timber so treated as in unprepared timber. Solutions of metals, such as zinc, copper, and iron, were also infused in the wood, but proved of no value for the purpose of defense against the mollusk. Some of the properties of coal tar have been found effective, but,

in the pure state, are so soluble in water as to quickly wash out. It was found by experiment that, when combined with creosote oil—which is a colorless fluid of strong antiseptic qualities, distilled from wood—the properties of coal tar were practically insoluble in water, and that the oil remains in timber after years of submersion as strong as when first injected. This result seems to be the perfection of prevention, for creosoted piles and timber which have been exposed to the teredo for as many as forty years show no evidence of having at any time been attacked, and are as good as when first placed in the water.

It is impossible to say what there is in creosote oil which makes it destructive to animals of cold blood. It seems, to those who have studied the matter, that, aside from being obnoxious in itself, the creosote oil so changes the appearance and smell of the wood that the teredo fails to recognize it as such.—*N. W. Lumberman.*

[Translated for the SCIENTIFIC AMERICAN.]

THE PHYLLOXERA OF THE OAK.

THE phylloxera of the oak differs but slightly from his congener of the grape vine, as has been shown by the communications of M. Balbiani, at least in form and habits. Like the phylloxera of the grape vine, the oak parasite presents in the course of his development five states or successive ages, and these ages are separated from each other by a moult, a change or casting of the skin caused by the marked growth of the body. The first age begins with the creature's emergence from its egg. It is then remarkable for its extreme minuteness, and for the mammillary glands which cover its body, and for its transparency. During the preliminary stage, the insect increases little by little, and it is possible to study its brain, formed of two nervous ganglia from which shoot nerves to the eyes, these latter made up of three smaller eyes. These eyes are more developed in the phylloxera of the oak than in that of the vine, as the former lives in the light, whereas his brother flourishes in darkness. The brain also supplies the antennæ with nerves. These antennæ surmount the head and form vertiable horns furnished with sensitive hairs, they are more lengthened in the oak insect, shorter and more massive in the phylloxera of the grape vine. The antennæ in both species have two peculiar organs formed of a membraneous watch-glass shaped growth incased in a thicker frame. This organ is supplied with a large nerve. It has been asked whether this organ is connected with hearing, of which there seems some probability, as it is more highly developed in the phylloxera of the vine, which owing to its darkened habitats would find an enlarged hearing apparatus useful. The muscles of both species are numerous and strong. The oak phylloxera before suspending itself from the leaves of the tree becomes provided with very strong and much bent nails. The extremity of the feet are terminated in both species by a large hollow hair carrying a sort of sphere which plays the part of an organ for attachment. The latter feature is more developed in the phylloxera of the oak, which must maintain itself upon the lower surface of leaves.

Their digestive apparatus is ample and strong, their mouths are provided with three strong needles, which play the part of a perforating instrument. These needles are more solidly formed in the vine phylloxera, which must pierce the bark of the root, whereas the oak destroyer needs only to obtain his food from softer leaves. The perforating organ is sheathed at will in a tube that in turn is converted into a suction pump. The apparatus, both borer and exhauster, has a special strength due to its dimensions and to the auxiliary role it plays in the digestive tract. The digestive tract is composed of tube which barely exceeds in length the length of the body, and which presents many successive expansions. The first expansion surmounts the breathing organs, and the movements of its oscillating walls can be easily observed. The second swelling in the tube, plays the role of a stomach, it is relatively pale. Then succeed the intestines, of which the movements are incessant, comparable to those of a heart. These rapid movements seem to produce a current, which explains how an insect so minute as the phylloxera can absorb such large quantities of sap. Digestion is also in another way hastened by the action of large salivary glands near the head, and by numerous glands which appear like low knobs on the surface of the intestines.

The respiratory apparatus in the phylloxera has a special importance, since it is a part of the creature which must be attacked by the exterminator of these pests. These organs are made up of a series of ramified tubes called *trachea*. These and their divisions can be traced to the surface of the parts among which they are distributed. These tubes open by small mouths called *stigmata*. These stigmata are less numerous in the phylloxera than with other insects, and embrace four small abdominal pairs and two large thoracic pairs. These latter are placed between and at the point of origin of the legs. There is thus secured a protection for the stigmata in this portion of the creature's body. The phylloxera is thus especially armed against asphyxia, which explains its maintenance of life more or less long in water.

The circulatory apparatus of the phylloxera is very simple, consisting of a very thin tube dorsally placed. The interior of the body especially in the earlier stages of its growth is filled with fatty bodies which permit it in extremity to live at times without food. The reproductive organs are very rudimentary. The first moult of the phylloxera is interesting. The skin splits from front to back, and the creature glides out. The new skin is thin, and it is a favorable moment for the application of poisons. This skin soon thickens, especially with the vine phylloxera. After the second moult the distinctive characteristics of the two species become more and more pronounced; the legs and the antennæ of the oak pest continue to increase in size, while on the contrary these parts are proportionally reduced in the vine insect.

The reproductive organs have now reached their maximum size. They consist of a series of tubes in which the eggs are developed and which upon maturity pass outward. In the apterous females the eggs are susceptible of development without the concurrence of the other sex. The eggs themselves are provided with a thick covering, they are very numerous, and succeed each other with such rapidity that the destruction of the entire brood seems impossible. Soon however succeeds the formation of eggs destined to produce individuals of different sexes. As these insure the perpetuation of the species, they are deposited with more care, and are limited in number. In fact, according to the period of the year, the wingless female phylloxera can produce eggs intended to develop into male and female forms or into those resembling herself. The male eggs are recognized by their smaller size and red color, and the female by their yellowish tint and greater dimensions.

In the ordinary eggs of insects, immediately beneath the shell there appears a layer known as the blastoderm which forms the delicate body which in developing becomes the larvæ. In the phylloxera this blastoderm is purely protective, so much so that it becomes colored to screen the embryo from certain hurtful rays of the sun. We soon discover in the course of development an exterior bed of multiplied layers, perforated by numerous small canals permitting the air to enter to the growing embryo, and also a granular coating which arrests water and even permits the growth of the egg in the midst of that body. Then follows a third layer impermeable to light. As the creature develops, its various organs make their appearance, until it enlarges sufficiently to emerge. The breaking of the heavy covering follows. It is very remarkable. There is developed at the upper end of the blastoderm a ridge which forms a small saw whose teeth interfere and destroy the shell covering. This latter falls apart in two halves, and the phylloxera commences its attacks on the oak leaves.

Many phylloxera only reach this third stage of growth, or so-called age of the wingless female, whereas others undergo a third moult, indicated by their red color, and they pass to the state of nymphs. During this fourth age the oak phylloxera passes through a series of modifications of which the most important consist in the relative development of the legs and of the antennæ, and in the appearance on each side of the dorsal region of two mamillæ whence start the rudiments of wings. Soon the envelope of the nymph falls away, and the new organs of locomotion appear, which characterize the winged state.

The phylloxera now takes to flight, and one is astonished at the minute size of this ineradicable pest. The smallest flies which crowd about us during twilight seem colossal as compared with these atoms. The creature in this stage has greatly developed powers of seeing, hearing, feeling, and is also provided with stronger limbs for attaching itself. It exerts itself most ingeniously to hide its eggs effectually, and its strengthened senses materially help it in its attempts.

The sexes issuing from the eggs of the winged phylloxera differ considerably from those produced from the eggs of the apterous female, especially in the atrophy or arrested development of the digestive tube.

Among the individuals born of the apterous mother this alimentary tube was very appreciably developed, although without an upper orifice. Among the individuals, on the other hand, arising from the winged mother it is reduced to a simple fusiform sac. In short, with those forms whose special end is to produce new eggs, this element of the creature's economy is diminished in importance.

This difference in the character of the individuals produced from the eggs of the wingless or winged female form seems to depend somewhat upon atmospheric conditions. When the eggs are laid of the wingless, and especially of the winged form, the cold weather has arrived. The effect ordinarily upon the eggs of other insects is to arrest development, but, on the contrary, with the phylloxera the reverse follows, and development appears hastened; but as it cannot be exerted upon all parts of the embryo, the essential organs of reproduction are matured at the expense of the other parts of the organism. The winter eggs are fitted to endure more exposure than others.

M. Babiani has communicated to the French Academy some observations upon the hatching of the winter eggs, and upon the appearance of the first spring generation, which though approaching the normal type preserve some of the characteristics of the sexual individuals who produced them.—*Victor Lemoine, in Revue Scientifique.*

THE MUSK RAT (FIBER ZIBETHICUS).

By E. GREGORY, Lindsay, Ont.

ABOUT two years ago Mr. Cristiani published an article extolling the fragrant properties of "American musk," and saying at the conclusion that it can be substituted for the more expensive Russian or Tonquin musk. As the musk he alluded to is taken from the so-called musk rat or musquash, which abounds in Canadian waters, and is very common in the numerous lakes and streams near which I reside, it seemed to me desirable that I should collect all the information I could obtain about the habits of this little animal, and about the properties and probable utility of the musk it produces.

In front of me as I write are the beautiful waters of Sturgeon Lake, stirred into life and motion by a strong southwest wind. The shore on which I have camped is low, but covered with hardwood to the water's edge. Sturdy oaks predominate, but not far off is a magnificent grove of maple. The lovers of fruit will also find in the neighborhood chokecherries, wild plums, gooseberries, raspberries, blackberries, and also a few whortleberries and cranberries. The opposite shore, about three miles off, is also low, dotted with farm houses and clearings, and having a stony beach, covered with drift wood. Down this lovely water, some two hundred years ago, swept Count Champlain, leading a band of Indians to attack a settlement of their brethren of a different tribe, who lived on the shores of the lake which now bears his name.

Into Sturgeon Lake run several small streams and rivers. About forty years ago, for purposes of navigation and to give water power, a dam was built at the outlet, which, raising the water, had the effect of covering a great deal of low land on each side of the creeks and rivers. The trees were all killed by the excess of moisture, and their dead trunks and branches left standing give the place so weird a look, that it has been named the "drowned land." This and kindred localities are favorite haunts of the musk rat, and here in some pool, among the dead and decaying legs, he builds his nest. It is two and sometimes three feet high, of a roundish conical shape, something like an earthen bowl inverted, and is composed of pieces of stick, weeds, and dried leaves. The inside is commodious, and is warm, comfortable, and soft.

There are two apertures, an entrance and an exit, and they are differently built. Both terminate under the water, so that the animal has to dive both in leaving and returning to his nest. The entrance is built as a gradual slope up to the floor of the lodge, so that he can easily run up it, but the exit is a precipitous descent down which he must jump into the water. In this nest he stays all day long, leaving it to search for food in the night or early gray of the morning. In summer he sometimes burrows in the bank. Occasionally a rat more venturesome than his fellows may be seen swimming a stream in broad day light, but this is not common. The musk rat is amphibious, and spends a great deal of his time in the water, but commonly has only one method of leaving or returning to the bank. At the edge of every body of water are numerous fallen trees, the ends of which rest on the bank, and the other extremities under water. He chooses one of these as his pathway, swims to it, runs up to the bank, gets what he needs, and returns down the same log again. This habit is taken advantage of for his destruction.

Sometimes in the early evening the trapper goes in his canoe with his ax and his traps, and, having discovered by marks best know to himself which log his prey has chosen, he cuts out a chip just below the water's edge, and in its place puts a trap, with two murderous steel jaws, but no teeth, for fear of injuring the fur. Over this trap the poor rat must go both in leaving or returning to the water, and he is thus nearly sure to step into it. These traps are visited night and morning. The fur is the part of the animal desired, and the rest of the carcass is thrown away as a general rule, but is sometimes eaten. The hunter gets from eight to fifteen cents for each skin according to the scarcity of the commodity or the demands of fashion, and many a fine seal-skin set is in reality nothing but dyed musk rat. I said that the carcass was eaten occasionally. This occurs principally in winter, the flesh being out of season in the summer. I have myself eaten it in the latter part of September, but the dish was insipid.

With the Indians, however, it forms a constant article of diet at their winter feasts. The musk sacs are placed in pairs, one on each side of the genital organs, and connected by a cord passing in front. They are underneath the external skin. All summer long and far into the fall these sacs are very small, but toward spring they increase in size, and about the months of February and March they attain their largest size and strongest odor. I have, indeed, been shown some, very small and useless, said to be the product of the female, but other trappers have contradicted this, and so the matter is doubtful. About a year and a half ago, in the latter part of March, I obtained from a hunter half a dozen of the recent sacs. They ranged from three-quarters of an inch to two inches in length, by about an inch in breadth, were similar in shape to the well-known sacs of beaver castor, but were of a light color, somewhat like the white meat of a chicken.

They were filled, apparently, with an oily fluid, of a strong musky odor, but which had a putrid smell. Being very busy I hung them in the sunny window of a wareroom to dry, where they were allowed to remain about two months, but though they filled the room with their musky odor, the putrid smell remained, and they never completely dried. At the end of that time they were cut up, and found still to contain an oily fluid, and much membrane, but nothing at all approaching in appearance to grain musk. The putrid smell never left them. Maceration in diluted alcohol extracted the odor, and a passable perfume was obtained. But the putrid taint still lingered, and I scarcely considered the experiment a success. Perhaps it would be possible, by a more careful method of drying, to avoid the odor of decay, and if that can be managed, I think a very agreeable perfume might be extracted.

The little animal from which this product is obtained is not truly a rat, nor does it belong to the same family—*Muridæ*—but is more nearly alied to the beaver—*Castor fiber*—while the musk rat is *Fiber zibethicus*. It is much larger than the common rat, and its fur is reddish brown, and quite long. Its tail is round, but slightly flattened at the end, and it is said he steers with it. Its two hind feet are webbed, and its front ones partially so. It lives on the roots and young bark of trees and shrubs, being very fond of the root of the water lily. It is capable of being tamed. A friend, some years ago, had three or four running about the house like kittens, completely domesticated. Trappers describe them as a very clean animal.

There are three other animals also going by the name of musk rat, which might possibly furnish a fragrant musk. These belong to the family of the shrews, and have the upper lip elongated into snout, or short proboscis. Two are species of the Mygale—one a native of the Pyrenees and the other of the south of Russia; and a third, called the Sondeli, is a native of India, which often utterly spoils provisions through the persistency and strength of its odor.

Some portion of the foregoing is from personal observation, but a great deal from conversation with trappers. But as I have taken some pains in comparing different statements, I think I have not been deceived.—*Canadian Pharm. Journ.*

ANTIQUITY OF MAN IN AMERICA.

AT the last meeting of the American Antiquarian Society, Frederick W. Putnam, Curator of the Peabody Museum of American Archæology at Cambridge, made a few remarks bearing upon the antiquity of man in America, based upon objects recently received at the Museum.

He presented photographs of four blocks of tufa, each containing the imprint of a human foot. These blocks were cut from a bed of tufa sixteen feet from the surface, near the shore of Lake Managua, in Nicaragua, and were obtained by Dr. Earl Flint, who has been for several years investigating the archæology of Nicaragua for the Museum, and has forwarded many important collections from the old burial mounds and shellheaps of that country. The volcanic materials above the foot-prints probably represent several distinct volcanic eruptions followed by deposits of silt. In one bed, apparently of clay and volcanic ash, six and one-half feet above the foot-prints, many fossil leaves were found. Specimens of these are now in the Museum, and their specific determination is waited for with interest. While there can be no doubt of a great antiquity for these foot-prints, only a careful geological examination of the locality and a study of the fossils in the superimposed beds will determine whether that antiquity is to be counted by centuries or by geological time.*

*Since this notice was printed in the volume of Proceedings, the Museum has received from Dr. Flint a representation of a vertical section of the quarry 300 yards from Lake Managua, as follows:

Surface soil	12 to 18	inches.
Hard Tufa	20	"
Seam	..	
Hard Tufa	20	"
Seam	..	
Hard Tufa	17	"
Seam of black mould	..	
Compact Tufa used for building purposes	28	"
Seam of black mould	..	
Hard Bluish ash and Clay, containing fossil leaves	14	" (This layer increases to 15 feet to the South and Southwest.)
Hard yellow Clay (native name *Tal-petate*)	12	"
Scattered Pumice	2	" Variable.
Sand	7	"
Compact Tufa used for building	47	"
Seam	..	
Compact Tufa	6	" Variable, 5 to 7 inches.
Dark Sand	1	"
Hard Tufa, dark	3	"
Sand	1	"
Foot-prints on surface of Compact Tufa (quarried for building purposes).	= 15 feet 9 inches to 16 feet 3 inches of materials above foot-prints.	

This bed of tufa is forty-seven inches thick, and rests upon the original soil, containing stems and leaves; probably the former level of the lake.

He also exhibited a portion of the right side of a human underjaw which was found by Dr. C. C. Abbott in place in the gravel, fourteen feet from the surface, at the railroad cut near the station at Trenton, New Jersey. It will be remembered that in this same gravel deposit Dr. Abbott has found numerous rudely made implements of stone, and that in 1882 he found a human tooth about twelve feet from the surface, not far from the spot where, as he states, the fragment of jaw was discovered on April 18, 1884. Both the tooth and piece of jaw are in the Peabody Museum, and they are much worn, as if by attrition in the gravel. That they are as old as the gravel deposit itself there seems to be no doubt, whatever age geologists may assign to it, and they were apparently deposited under the same conditions as the mastodon tusk which was found several years since not far from where the human remains were discovered. While there is no doubt as to the human origin of the chipped stone implements which have been found in the Trenton gravel, a discovery to which archæology is indebted to Dr. Abbott, the fortunate finding of these fragments of the human skeleton adds to the evidence which Dr. Abbott has obtained in relation to the existence of man previous to the formation of the great Trenton gravel deposit.

LIFTING WHEELS FOR COPPER MINES.

AT the copper mines of the Calumet and Hecla Mining Company, on the borders of Lake Superior, the amount of refuse resulting from the process of mining is sufficient to cover an acre of ground one foot deep every forty-eight hours. The disposal of this enormous mass is only accomplished by great labor and at heavy cost. It cannot be drained to a locality where it would be out of the way, as the elevation of the mines is not sufficient. The inconvenience, trouble, and expense consequent upon the present method of handling the waste products have been done away with, and the question solved, by the use of wheels of mammoth proportions, which raise the debris to such a height that it will flow off into the lake. Two of these wheels have been ordered: one was completed some time since and sent to the mines; the other is nearly finished, as shown in our engraving, which represents it standing in the shops of the Dickson Manufacturing Company, at Scranton, Pa., where both wheels were built.

The shaft of the wheel is made of gun iron, and is 30 inches in diameter. It rests on ponderous pillow blocks having universal bearings. From the octagonal hub radiate wrought iron arms, which are pyramidal in form, and are built up of four corner pieces converging toward the periphery of the wheel, and united together by lattice work. The ends of the arms, known as the bucket segments, are of cast iron, and to them are bolted the spur segments and buckets. All the parts are held together by turned bolts that were driven in reamed holes.

The spur gear on the periphery is made up of sixteen pieces, is 43 feet in diameter at the pitch line, $4\frac{5}{8}$ inch pitch, 12 inch face; all the teeth, 352 in number, have been cut epicycloid, and are mathematically correct. There are twenty-five double elevating buckets or inverted pockets on each side of the spur gear, making 100 buckets in all, which are stationary on the inside of the periphery of the wheel, and are capable of scooping up at a single revolution nearly 2,000 gallons.

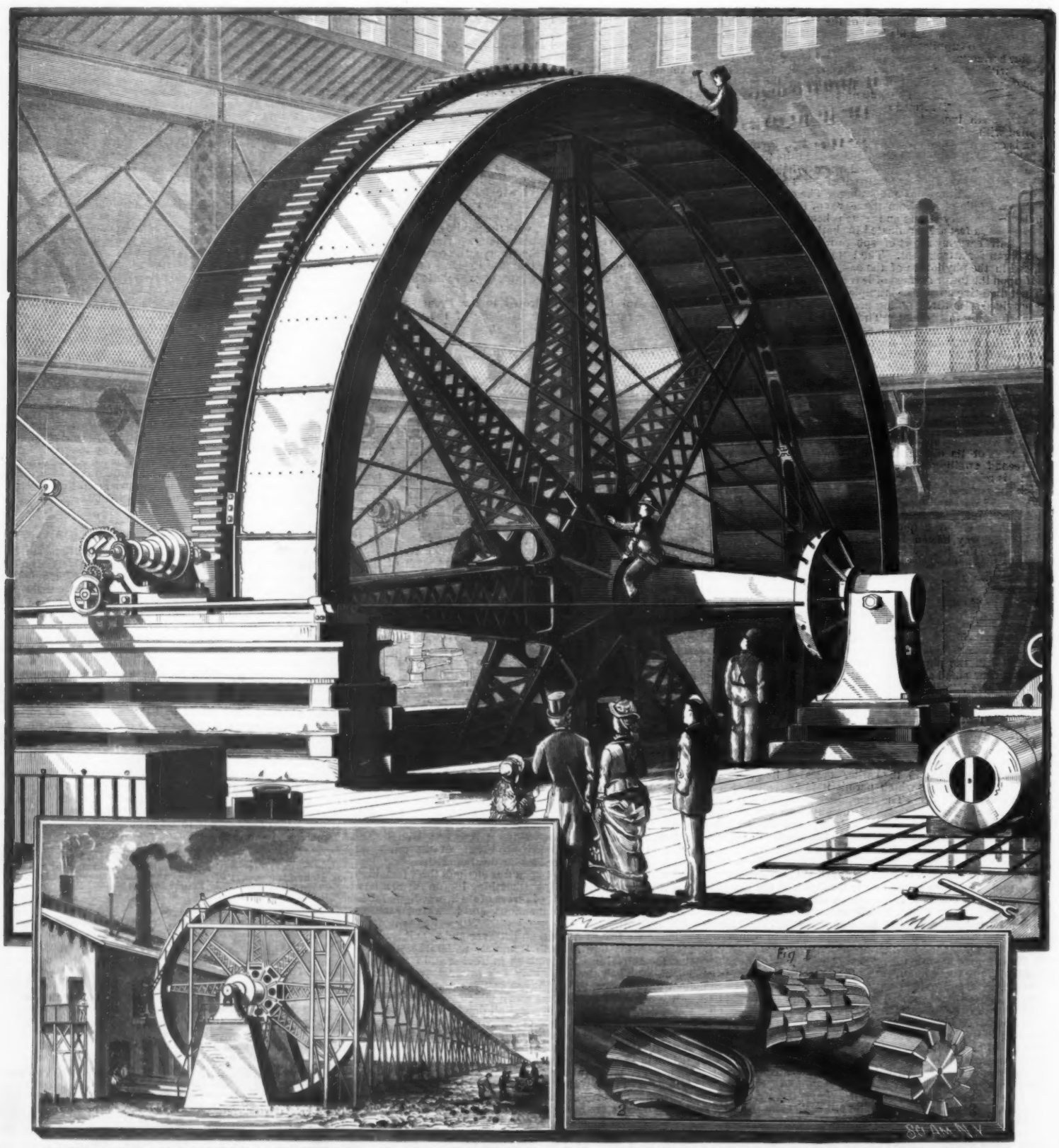
The most important feature of the wheel is the manner in which the spur was constructed. The teeth were laid out by hand, a prick-punch mark locating each tooth. The teeth were cut by an ingenious device suggested by such a great task and specially planned for this work. The work was done by two cutters located one on each side of the wheel at diametrically opposite points. One of these cutters is shown in the engraving. The rest holding the tool traveled on a bed placed just outside the periphery and in a line at right angles to the plane of the wheel. Figs. 1, 2, and 3 represent the cutting tools used; Fig. 1 was used as a stock cutter, the peculiar shape and arrangement of its cutting edges enabling it to rapidly and easily clear itself; Fig. 2 was used as a finishing cutter; and Fig. 3 was used to cut the face of the teeth. So successfully did the tool shown in Fig. 1 work, its clearing powers permitting deep cuts without the danger of heating, that it is probable that it would be used alone—to the exclusion of the finishing cutter—in another job of this kind. By working upon both sides of the wheel at once the time occupied in milling and cutting the teeth was 215 hours, and the probability is that with the old plan of milling it would have taken four times as long.

The same process was used in the construction of the machinery for driving the Brooklyn Bridge cable, the company having received both orders at the same time.

This wonderful wheel is to be used to remove the refuse from the copper mines. It will be set in solid masonry, with arches through which the launders used for washing the ore will pour their contents, to be taken up to the buckets already described and deposited in outlet launders placed at an elevation of 40 feet, which will afford sufficient impetus to carry the waste into Lake Superior.

The whole will be driven by a steel spur pinion, the shaft of which will be actuated by an engine of 175 horse power. It will make about four revolutions per minute, lifting 8,000 gallons in that time, or 480,000 gallons each hour.

The combined weight of both wheels is 124 tons, and their cost in place will not be less than $50,000.



THE GREAT LIFTING WHEELS OF THE CALUMET AND HECLA MINING CO., LAKE SUPERIOR.

The Dickson Company is also building two of the largest locomotive fire box boilers ever made, being 1,000 horse power each. They are made of steel plate nine-sixteenths of an inch thick. Each boiler will contain 199 three inch lap-welded tubes 16 feet long. These boilers will weigh 61 tons each, and will be used to work the immense machinery of the Calumet and Hecla Mining Company.

AN ENGLISH TESTING LABORATORY.

OUR best technical colleges are recognizing the importance of impressing upon the minds of students the behavior of iron and steel under increasing loads. A mere announcement that iron will stretch elastically say 25 per cent. before rupture makes but a faint impression upon the mind if unaided by positive experimental demonstration. Therefore, in order to enable students to realize how far and under what loads iron and steel or other metals can be bent, crushed, or extended, testing machines have been set up in some of our higher educational establishments. The 100-ton machine we are about to describe is one of this class made by Buckton & Co., of Leeds, and erected during the course of last year in the laboratory of the Royal Indian Civil Engineering College, Cooper's Hill. Essentially its principle is the same as that of the single-lever 50-ton Wicksteed machine, whose place it takes, and which has been previously described in these columns, but in accessory qualities it embodies many improvements suggested by Prof. Unwin, which greatly distinguish it from the previous machine of lighter build and lower testing power.

Fig. 1 is a general view of the new machine and the interior of the engineering laboratory. The machine has a maximum testing power of 100 tons. Hence, with inch bars the maximum unit of stress is 100 tons per square inch, and for other sections varies inversely as the area submitted to test. It is in principle a lever of the first order, the length of the short arm being 4 inches. The ratio of leverage varies with the position of the running weight saddled on the lever, and attains a maximum of 50 to 1 when the weight has reached the outer end of the long lever arm. The system is in equilibrium with the running weight behind the fulcrum arm; consequently the load graduation extends to a point behind the fulcrum. Motion is communicated to the saddled weight by indirect transmission to shafting from a prime motor Clerk gas engine, indistinctly visible in the background behind the drilling machine on the right of the figure, and by fast and loose pulleys and screw shaft to machine. The motion of the riding weight is started, stopped, or reversed by the fast and loose pulleys, which can be worked by hand when a delicate movement is necessary. Motion is conveyed to the compressor plunger by a somewhat similar arrangement, clearly shown in the center of the illustration. The necessary counterpressure is produced by the action of this horizontal plunger upon a ram in a vertical cylinder of cast steel, fitted to the frame and contained below floor in the line of specimen under test. The plunger acts upon the ram through an intermediate hydraulic seal or water piston which effects a steady and continuous increase of pressure. The maximum counterpressure attained is about 2 tons per square inch of ram area. The machine has two knife edges, each 23 inches long; one used as a fulcrum, the other for the suspension of the shackles. The shackle joints are somewhat novel, consisting of a rounded end fitting into a halved semispherical cup or socket, a type of joint which seemed to us very elastic and apt to relieve any oblique twists or local strains. The diameter of the pump plunger is about 3¼ inches, that of the ram about 9 inches.

Fig 2.

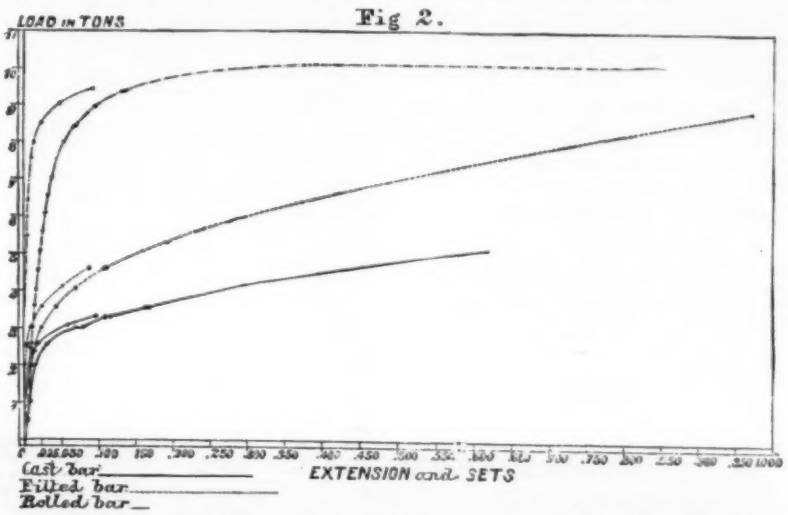


FIG. 2.—CURVE SHOWING EXTENSION AND SET OF DELTA METAL.

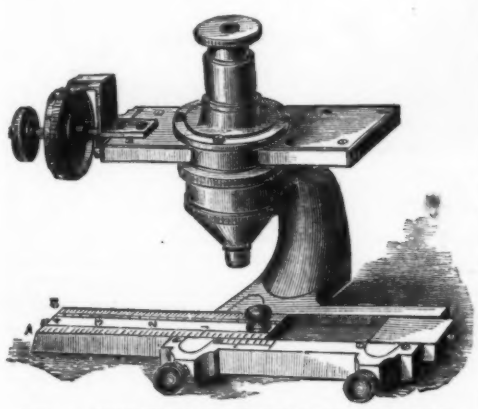
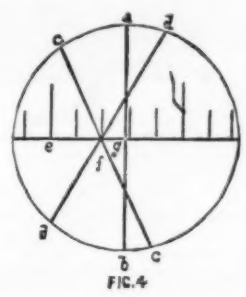


FIG. 3.—PROFESSOR UNWIN'S MICROMETER.



Diagram, Fig. 2, gives the plotted results of a series of actual experiments upon three small bars of Delta metal 0·62 inch diameter and 8 inches length, made and kindly furnished to us by Professor Unwin. There are two curves in each bar, one for permanent set, the other for total extension, the intercept between them showing the elastic extension. These curves appear exceptionally regular and continuous, bearing in this respect a close resemblance to a steam expansion curve. It would appear from the diagram that Professor Unwin prefers to enlarge the scale of extensions rather than the scale of loads, an expedient which, in our opinion, tends to bring out in relief the salient features of the test. Apart from a slight deviation in the curve of the cast bar, the diagram exhibits no break down or line where extension continues unaccompanied by increase of load. Another pleasing characteristic of the curves is the approximate constancy of the elastic extension, the greatest variation in this respect being exhibited by the cast specimen.

Fig. 3 is an illustration of the micrometer with which Professor Unwin took the extensions plotted in Fig. 2. The measurements are first approximately taken by drawing out the graduated scale, and then minute differences are determined by using a circular vernier in the following way: The double scale, A B, Fig. 3, is first set by touch to the distance between two polished steel pins fixed on the bar, and this distance is read off provisionally on scale, A, divided into tenths, and subdivided by a vernier into hundredths of an inch. Practically, within the limits of elasticity, only the nearest one-tenth is required. Having read the extension on scale A within one-tenth of an inch, the operator next looks through the microscope at the magnified scale, B, divided into tenths of an inch to agree with the first division on A. Each of these tenths is subdivided into five parts, or to one-fiftieth of an inch. Thus the field of view presented to the eye is similar to diagram, Fig. 4, where *a b* is a fixed cobweb coincident with the vernier zero of scale A. The lines *c e d d* represent crossed cobwebs displaced by turning the graduated head of the micrometer screw. When the crossed cobwebs coincide with *a b*, the graduated head is at zero. Two turns of the head move the cobwebs one small division of scale B, and as the circumference is divided into hundredths, it reads within one-ten-thousandth of an inch. Up to the limit of elasticity the scale, A, requires to be read only once. Beyond this limit the stretch is so great that the readings to hundredths on scale A are sufficiently accurate. This adaptation of the micrometer as an end measure is certainly ingenious, and more likely, we should think, to give correct results than the plan of following the extension on the vertical scale of a cathetometer.—*The Engineer.*

[SPRINGFIELD REPUBLICAN.]

THE DYNOGRAPH CAR.

P. H. DUDLEY'S dynograph car, which has recently finished its automatic inspection of the Boston & Albany track, contains some remarkably ingenious applications of delicate machinery to technical work, and is so completely automatic in its working that, with a single exception in a minor detail, Mr. Dudley does nothing except to keep the recording machine supplied with paper and interpret the results after the machine writes them down for him. The car is about the length of an ordinary passenger car, and contains, in addition to the machinery-room at the rear end, a kitchen, parlor, and bedroom, in which Mr. and Mrs. Dudley live while en route. The machinery, which by levers and electricity works the registering apparatus in the car, is

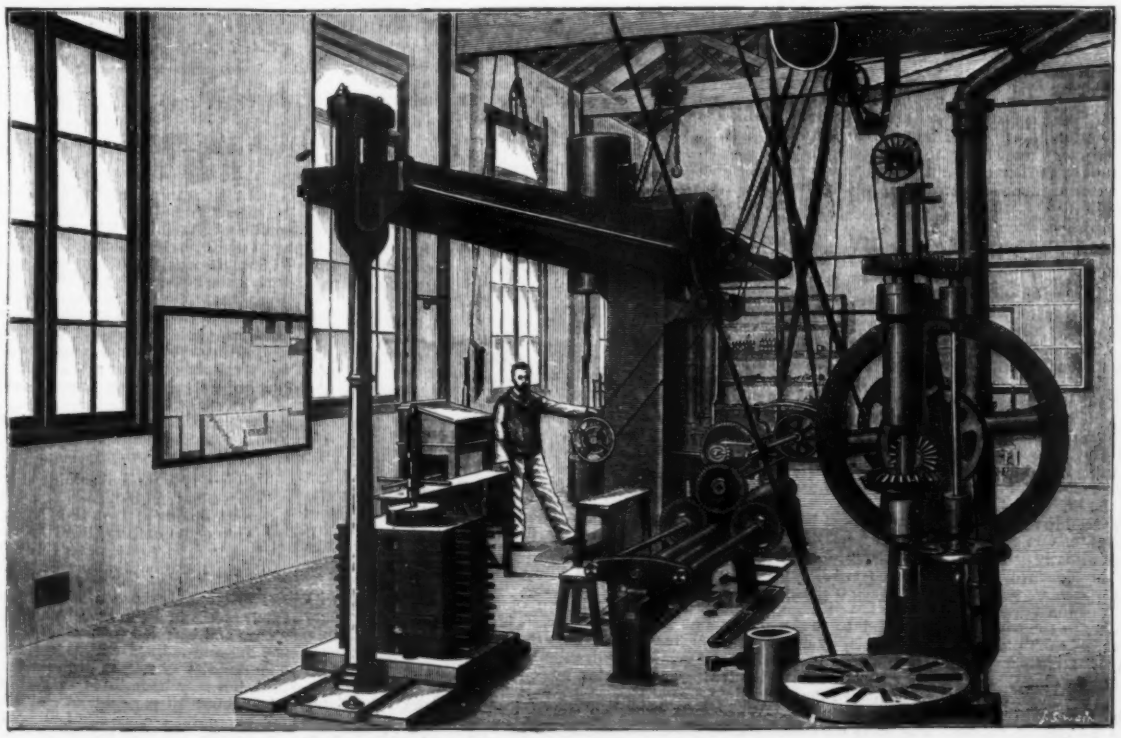


FIG. 1.—AN ENGLISH TESTING LABORATORY.

located under the car and over the rear six-wheel truck. The results are registered by the graphic method of curves on one or both sides of a base line, by twenty pens, under which ruled paper passes at the rate of 8·8 feet to the mile of track. A curved top table supports the paper, and by connection with the axles of the track beneath a certain amount of the paper is passed over this table for each revolution of the car wheels, and as these wheels are of a carefully measured circumference, the same amount of paper runs over the table for each mile of track, regardless of the speed of the train. The recording paper is thirty inches wide and is blank as it enters the table, but before passing under the recording pens it is automatically ruled into five sets of fifteen lines, each one tenth of an inch apart.

As the rear end of the dynagraph car is weighted to twenty tons, or to five tons more than the heaviest weight which comes on any truck of the largest sleeping car, the wheels of its trucks follow closely the slightest surface depressions in the track, and also press it down in any place where a rotton tie or defective joint allows the rails to spring. The central wheels of the truck are connected by delicate levers, which change the vertical to a horizontal mo ion, with a pen for each line of rails, and these pens record the extent of the deviations from the proper alignment of the rails. An air pump connection with these wheels also spatters blue ink on the rails wherever the pens register a low place, so that the section men can tell at a glance what places and parts of rails need to be raised to get the whole track up to the proper level. A deviation of one-fourth of an inch or more from the general alignment is thus registered and marked. One pen for each line of rails also registers the number of low places or blotches of ink on the rails, together with their exact location referred to the nearest mile-post, and an ingenious cog apparatus counts up and registers in tens and hundreds the number of such defective places in the track. Another pair of pens registers on the scale in inches and feet the total variations from the proper horizontal alignment to each mile of track, or if desired in each rail passed over. The distance traveled by the car is registered by a cog connection with the car-wheel axle, and an apparatus set when the first mile-post of the trip is passed notifies Mr. Dudley by ringing a bell just before each succeeding mile-post is reached to touch the pen connection which registers these mile-posts on the paper and serves as a check on the wheel register of distance traveled. Another pen shows on the record paper whether the track at any point is a curve or tangent, and its companion records the comparative elevation of the outer and inner rails on each curve. Two pens by chronometer attachment register in seconds and tenths of seconds the running speed of the car at any part of its journey. Two pens are connected with disks which run along on the inside at each line of rails, and record the gauge of the track to show any "spreading" of the rails, and also, even when the gauge is correct, record otherwise imperceptible defects in straightness of the rails due to careless rolling-mill work, and by which the jarring motion in cars passing over the track is increased. A special pen is used to register vibrations of the car body and show the riding condition of the track. A penny placed on the rail will cause a perceptible mark by this pen when the car passes over it. A coupler spring attachment can also be used to show the exact amount of energy exerted by the engine pulling the car at any point in the journey.

These records are all made at the same time and on the same paper, and can therefore be compared, and an exact report made by Mr. Dudley, showing not only the amount and kind of work required to perfect the road-bed, but also the precise places referred to mile-posts on the road where the work should be done. The registration of these machines is so perfect that Mr. Dudley can, if the rails are comparatively new, tell when passing at the rate of twenty miles an hour over a railroad what mill rolled the rails on which he is riding, and knows at once when passing from rails of one manufacturer to those rolled by a different maker. From the record thus made Mr. Dudley makes up a profile map of the road, which by curved lines shows, on a scale of one-fourth of an inch to the mile, the following things: First, any irregularities of gauge along the line; second, defects in horizontal alignment of the rails; third, the grades along the railroad; fourth, the condition of the track at any point, compared with a perfect track; fifth, whether, and how much the track can be improved by labor, or whether new rails alone are needed to make it more perfect; sixth, the brand and kind of rails used on each mile of road; seventh, the number of years each rail has been in place; and eighth, the comparative percentage of tangents and curves per mile of road. This map completed costs $2.50 per mile, the high price coming mainly from the immense amount of work required to interpret the results, and the delicacy and cost of the instruments used in the work. Mr. Dudley is the inventor of all his instruments, and inspects each year from six to ten thousand miles of track, living on his car during these trips. From three to five thousand "miles" of paper are kept in the car constantly, and fifteen gallons of ink per 100 miles of track are used in "spotting" low places.

THE NEW AQUA-AERIAL OR WAVE SHIP.

IN designing this vessel the inventor's object has been to render it capable of skimming along or over the surface of the water, in place of having to plow its way through it, and thus avoid the chief cause of resistance encountered by ordinary vessels, viz., wave-making.

It is intended for express mail and passenger service, and is of shallow draught when at rest, and it is stated that its draught decreases with the increase of speed.

The first of our two views shows the vessel heeled over, so as to expose the bottom and keel, and viewed from a point slightly aft of the midship section; the other shows the vessel as viewed from a point looking toward the starboard bows; the four diagrams give a longitudinal section, and transverse sections at the lines ABC.

From these it will be seen that the bottom of the vessel is formed as a double series, one on either side of the keel, of inclined planes, *c*, longitudinally parallel and placed one after the other, and preferably concave in cross section toward the bows, as shown in transverse section line, A. Each plane throughout the length of the vessel contributes, as well as the first one of the series, to the lifting of the vessel to the surface as it progresses, as each plane after the first is, by a peculiar arrangement of atmospheric ducts, *b*, rendered independent of the preceding plane, or of the effects of its action upon the water. The ducts communicate between the atmosphere and the bottom, and the passage of air through them is regulated by self-acting valves. The bows curve downward from about the deck level, and merge into the front of the first plane of the bottom. The watertight compartments, *a*, of the sides of the vessel merge into a kind of platform at the stern, by which eddy-making is avoided.

It is claimed for this form of construction that it will possess the quality of steadiness to an extent unattainable in the ordinary form of hull, rolling being prevented by the combined action of the planes of the bottom and the air ducts in connection with them. Any tendency to roll is immediately counteracted by the air-ducts on the rising side of the vessel closing automatically, and thus creating a vacuum under that side of the vessel, which will tend to bring it down to the normal level, while the greater pressure exerted on the water by the planes on the opposite or more submerged side will tend to send that side up to the normal level.

The form of the hull lends itself to great structural strength, combined with lightness, and as narrowness of beam is no object, scope is given for the planning of saloons and other apartments on a scale that would be impossible in ordinary vessels.

The inventor, Mr. J. Dickie, of 1 East Parade, Leeds, has taken a novel and somewhat bold step in thus departing from the ordinary lines of construction, and we hope that his invention will meet with the success that it deserves.—*Marine Engineer.*

MORTARS AND CEMENTS.*

By JOB TUTHILL

THE demand for mortar is as ancient as the art of building, and from the "slime" of the tower of Babel to the cement of to-day mortars have consisted of pulverized earthy substances in great variety, from pure clay to the best modern cement, and of all degrees of value from worthlessness to the capability of attaining a degree of hardness equal to that of the best building stone.

The oldest example of the use of lime as a cementing material is found in the monuments of Egypt, the mortar which joins the stones of the Pyramid of Cheops being precisely similar to modern mortars of lime and sand. The knowledge of the properties of lime descended from Egypt to Greece, where a different climate and an ingenious people developed many of its uses unknown to the Egyptians. Greek colonies introduced their processes into Italy, and the ruins of works built by the Romans bear witness to an extended knowledge of the value and use of lime, sand, and pozzolana. Hydraulic lime and the modern product of cement were unknown to them, and for hydraulic purposes they used pure lime mixed with a volcanic substance called pozzolana, and small fragments of bricks, forming thus a concrete that hardened under water.

It is not known at what period the fact was discovered that certain limestones would yield a lime or a cement capable of hardening under water. The French writer Vicat in the beginning of the present century was the first to make an extended investigation of the laws governing the action of lime, and he was also the first to make an artificial hydraulic cement. Since then much time and study have been given to the subject, and much valuable information has been obtained.

Common mortar is a mixture of pure lime and sand with water enough to make a paste. The proportions in ordinary use are one measure of lime to five of sand. In hydraulic mortar and cement, hydraulic lime, possessing the property of hardening under water, or cement, takes the place of the pure lime.

When gravel, broken stones, broken bricks, or any substance to which the mortar will adhere firmly, are added, the mixture is called concrete or beton; hydraulic cement is now being used almost exclusively for the cementing material.

Lime is found in nature as a carbonate; usually combined with magnesia, silica, alumina, and a small amount of oxide of iron. These impurities give lime the capability of hardening under water, or hydraulicity; and according to the varying proportions of these impurities limes are classified.

Lime and cement stones must first be calcined or "burnt" to drive off the carbonic acid; those containing less than ten per cent. of impurities yield what is known as pure, rich, or fat lime.

This when moistened with water combines chemically with it, giving off heat, increasing in bulk from two and one half to three times, and falling to powder, thus producing hydrate of lime. This absorbs carbonic acid from the air and therefore hardens slowly, passing back to carbonate, which process gives lime its value as a mortar; sand being added to prevent shrinkage and to increase its resisting to crushing. This change will only take place in open air, and therefore pure lime mortar cannot be used for construction under water.

The Poor Limes forming the second class are produced from stone containing from 10 to 20 per cent. of impurities, and are useless for mortar.

The Hydraulic Limes come next, containing from 25 to 35 per cent. of impurities. They slake slowly with a slight rise of temperature and an increase in bulk of about ⅓; they will set under water in from 1 to 20 days, but are not much used in this country, owing to the abundance of the next class, the Hydraulic Cements.

These contain from 40 to 60 per cent. of impurities, do not slake at all, and hence their bulk and temperature remain the same during mixing and setting, and they may therefore be used alone in a poor state. Deposits of natural cement stone are found and worked in a number of places in the eastern half of the United States, the best in Pennsylvania and Virginia. The principal deposit is found in the town of Rosendale, Ulster Co., New York, near the Hudson River. It was first brought into use there in about 1823, during the construction of the Delaware and Hudson Canal. Since then its production has steadily increased to from 1,000,000 to 1,500,000 barrels each season. The Rosendale quarries or ledges are of some twenty or more different strata, and vary from a cement that sets in three minutes to one that takes an hour and a half to set. The best cement produced there is a mixture of several strata in the proper proportions.

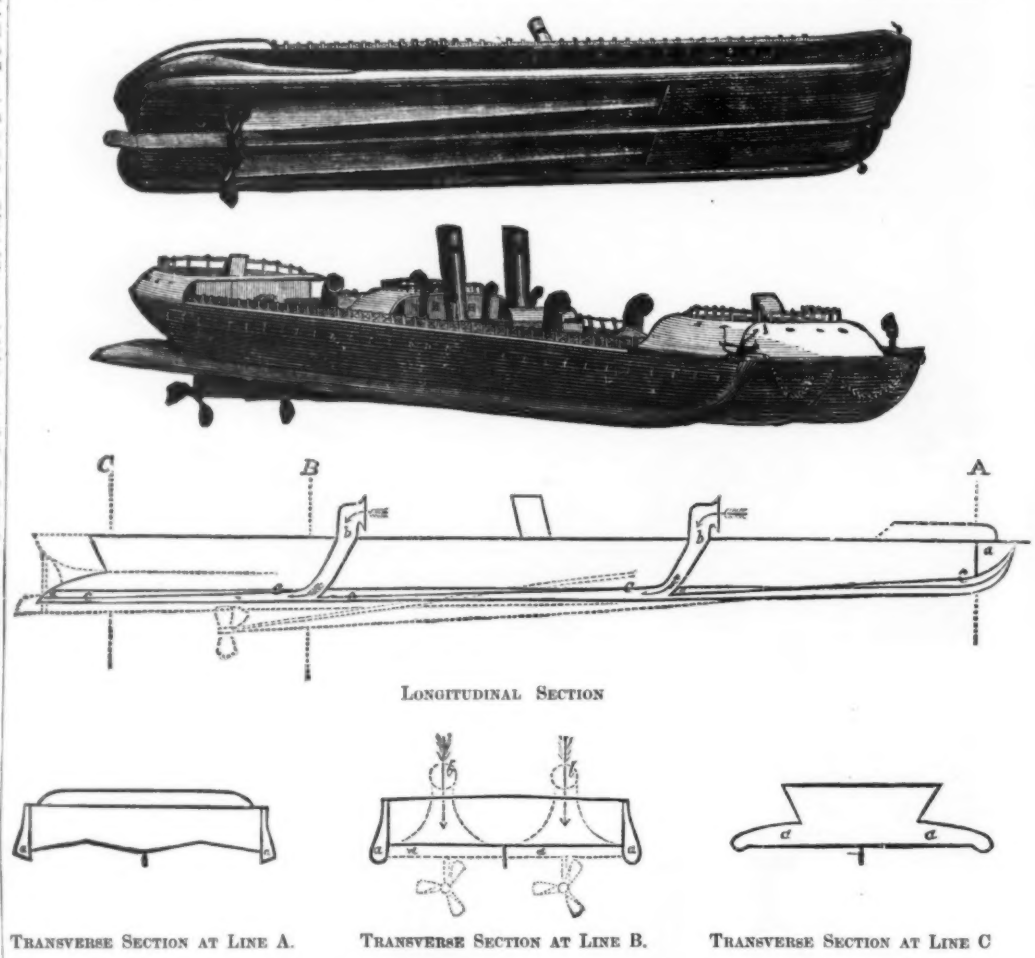
Analysis shows the following variations in the composition of the Rosendale stone :

	Per cent.	Per cent.
Silica, clay, and insoluble silicates	11·10	39·47
Alumina (Al_2O_3)	2·34	7 50
Sesquioxide of Iron (Fe_2O_3)	0·76	5 gg
Carbonate of Lime ($CaCO_3$)	28·48	46·00
" " Magnesia ($MgCO_3$)	14·48	39·04
Potassium and Sodium Chlorides	1·68	7·42

The stone is burned almost to vitrification, broken in small pieces in a cracker, then ground between French burr stones and barreled for market. Each barrel contains about 300 lb., and is lined with paper, to exclude air and moisture. The rapidity of setting declines from the time of leaving the mill, but may be restored by making the cement into balls with about 10 per cent. of clay and reburning. If the cement contains an excess of lime, it is safer to use after six six months, the lime becoming air-slaked by that time.

A mortar is said to have *set* when it has attained such a degree of hardness that its form cannot be altered without

* Papers of the Engineers' Society of the University of Michigan.



THE NEW AQUA AERIAL.

causing fracture; in common mortar this is accomplished when the lime has absorbed enough carbonic acid from the air to become a carbonate. The setting of hydraulic mortar and cements is due to the combination with the silica of the alumina and the lime set free from the carbonic acid by the process of burning; producing double silicates of lime and alumina, which further combine with water when mixed and undergo a species of crystallization; this combination taking place equally well, and under some circumstances more rapidly, in water than in air.

As the excellence of the cement depends upon the presence of lime, silica, and alumina, in the proper proportions to form the double silicates, by combining their ingredients in the right quantities, and excluding injurious substances, an artificial cement can be produced which excels the natural product. This fact has been taken advantage of, and our artificial hydraulic cements are the result. The best of these are the Roman and the English Portland, the former being similar to the Rosendale.

The English Portland is a mixture of clay, consisting chiefly of silica and alumina, and chalk or nearly pure carbonate of lime. The clay and chalk are ground roughly, mixed in the proportion of 1 to 3 by weight, and ground in water under edge runners. The mixture is then allowed to settle, the surplus water to drain off, and the mass is dried and kneaded into balls two or three inches in diameter, which are burned in a kiln at a white heat. After burning they are reduced to an impalpable powder, and the cement is ready for use. Unlike natural cement, Portland does not deteriorate by exposure to common dry air, and if kept for a month or two before using will improve. Its superiority is due to the close homogeneous mixture of the chalk and clay, and to the close approach to vitrification in burning. Uniformity of burning also increases the weight.

The English standard requires three tests: that the cement shall weigh 110 pounds to the struck Imperial bushel; that it shall pass through a sieve having from 1,600 to 3,000 meshes per square inch; and that its tensile strength shall be 200 pounds per square inch at the end of seven days, the first passed in damp air and the rest in water. American engineers require the somewhat higher standard of 115 pounds per struck bushel; that 90 per cent. shall pass through a sieve of 2,500 meshes per square inch, and some specifications require that there shall be a tensile strength of 250 pounds per square inch.

The time of setting of good cement varies from three or four minutes to many hours. Ordinary Rosendale when mixed with sand sets in about three-quarters of an hour; when used "neat," or alone, in about half that time. Portland sets in about three hours, becomes of a reliable solidity in about a day, very hard in a week, exceeds hard burned brick in three months, and is as hard as marble or sandstone at the end of a year; the rate and degree of the induration of Rosendale and Roman being a little lower. Quick setting is due to a great extent to under burning, and is not an indication of ultimate strength. It may be detrimental, as in warm weather, or on some constructions a partial set may take place before the masonry can be properly lowered and adjusted, any disturbance during setting being injurious. A quick setting cement may be made to set more slowly without seriously weakening it by adding to the paste from 5 to 10 per cent. of its bulk of lime paste. For structures exposed to running or to tidal waters a quick setting cement is most serviceable.

As a general rule, cements set and harden better in water than in air, although if the temperature for the first few days does not exceed 60° F. there seems to be no appreciable difference; with a higher temperature the cement dries instead of setting, and thus loses much of its strength. It attains its maximum hardness only after the lapse of many years, although after a year the increase is slight and of little importance, as most structures are completed and the strains the greatest before the end of that time.

It has been found in the testing of cements that the temperature of the air and water has a greater influence upon test of cements seven days old than had before been supposed. Thus pure Portland moulded in air at 30° F. and kept in water at 60°, had a tensile strength of but 158 pounds per square inch; while that kept in water at 70° had a tensile strength of 299 pounds, or nearly twice as much. Others moulded and kept for twenty-four hours in air at 60° and six days in water at 40°, broke under a tensile strain of 113 pounds per square inch, while those kept in water at 70° required 354 pounds, or about 2¼ as great a strain. The general effect of age, however, was to lessen the influence of the temperature and bring the tensile strengths nearer together; hence some contend that the standard time for breaking should be a month instead of seven days, the usual time now taken.

Sand retards the setting of all cements, and weakens Portland in about the following proportions:

1 part sand to 1 part cement gives 1-2 strength of pure cement.

2	"	"	1	"	"	"	1-3	"	"	"
3	"	"	1	"	"	"	1-4	"	"	"
4	"	"	1	"	"	"	1-5	"	"	"
5	"	"	1	"	"	"	1-6	"	"	"

Rosendale being reduced somewhat less.

Almost any U. S. cement of good quality, when mixed with sand in the proportion of 1½ or 2 parts to 1 part cement, will give a mortar sufficiently strong for most engineering purposes; a good Portland will give an equally strong mortar with 3 or 4 parts sand, and although costing from twice to two and a half times as much as the U. S. cements, may still be the more economical.

The sand should be clean, hard, and sharp, and if necessary should be washed to remove dirt and vegetable matter. It should not be too fine or necessarily of uniform size, different sizes being mixed with decided advantage. The water used should also be free from suspended dirt or vegetable matters. About one-half their bulk of water is required by both Portland and Rosendale cements to make a paste of the proper consistency; when sand is added, more water is required; the only safe guide is by trial on the work. A deficiency of water produces an imperfect chemical action and the full strength of the cement is not obtained, while an excess renders the mortar porous from its evaporation.

Cold appears merely to retard the action of setting, and if the mortar thaws equally no serious harm results, so that if necessary work may be carried on when the temperature ranges not much lower than the freezing point, care being taken that the mortar thaws equally upon both sides of the structure, otherwise an overthrow may be the consequence. Heating the sand and cement in freezing weather seems to a bad practice, especially if the mortar be placed in cold water afterward.

In any important work every lot of cement should be tested before being used. The engineer should reserve the right to bore with a long auger into any part of each barrel, and to reject every barrel from which the sample taken does not satisfy the specifications. Simple tests may be made by noticing its behavior while hardening under water with reference to the time of setting; whether it swells or cracks, indicating an excess of lime; its tensile and crushing strength per square inch; and when thoroughly set its resistance to the weather. The effect of frost may be tested by exposure to freezing mixtures.

The tensile strength is usually tested by pressing the paste or mortar of the proper consistency into brass or iron moulds, shaped somewhat like the letter I or the longitudinal section of a dumb bell; the smaller part giving the desired breaking area, usually 1 square inch, and the larger ends being clasped by the apparatus for breaking. The force is applied by means of a lever, usually a scale beam with a suitable vessel into which shot or sand is poured, thus producing a steadily increasing weight. The test pieces as a general thing are broken at the end of seven days, passed, the first in air and the remaining six in water. The transverse strength is tested by breaking prisms of the desired section upon supports a certain distance apart.

General Q. A. Gillmore, of the U. S. Engineering Corps, devoted several years to the study of the nature and action of limes, mortars, and cements. His treatise upon this subject contains the results of a long series of investigations and experiments, and is considered standard authority. Engineers having works of importance in charge have made a series of experiments and tests as to the qualities of different cements, many of the results of which have been published in the Transactions of the American Society of Civil Engineers, and contain much interesting and valuable information.

FILTER FOR SUGAR.—MANUFACTURE OF SUGAR WITHOUT BONEBLACK.

SOME time since, we called attention to a system of pockets intended to eliminate the impurities suspended in beet juices, avoiding entirely the use of boneblack. It would seem at first hardly possible at first to decolorize a sirup without the chemical or mechanical action of boneblack, so long used in all countries in sugar manufacture. The cost of this clarifying agent increases very considerably the price of sugar. It may be interesting to state, that during the campaign 1883–84 a large number of factories worked without boneblack, while others reduced the quantity used. The Puvrez filter was at first employed simply to filter the juices and sirups before they were run through the bone filters—this yielding the advantage of eliminating from the juices the worst suspended impurities, thus permitting the boneblack to work more satisfactorily and for a longer time without renewal. Many chemists assert, and experiments seems to

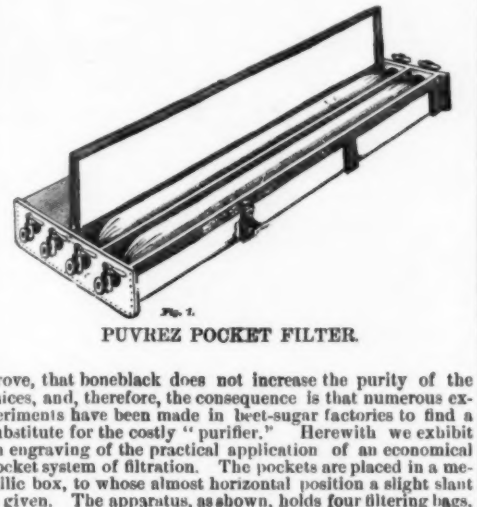


Fig. 1.

PUVREZ POCKET FILTER.

prove, that boneblack does not increase the purity of the juices, and, therefore, the consequence is that numerous experiments have been made in beet-sugar factories to find a substitute for the costly "purifier." Herewith we exhibit an engraving of the practical application of an economical pocket system of filtration. The pockets are placed in a metallic box, to whose almost horizontal position a slight slant is given. The apparatus, as shown, holds four filtering bags, so that two of the pockets may be emptied while the other two work; a change requiring only a short time. When the apparatus is working, juices and sirups filter through the pockets and are run off by a common gutter, placed at the bottom of the metallic box. The latter is covered by a door, which may be opened to clean or empty one of the pockets; but during the working of the filters it is advisable to keep it closed in order to retain, as far as possible, the heat of the circulating liquids. The boneblack, through which the juices are in some cases subsequently passed, may, it is said, be revivified with water only, without the tedious operation of the bone kiln. It is asserted that the cost of labor and fuel are thus much reduced, and the loss of sugar and boneblack diminished.

The economy resulting from this method, namely, partial suppression of boneblack, is difficult to calculate, but it is estimated at five cents per ton of beets worked, representing $1,000 for every 20,000 tons of root used. The factories where the filtrations of beet juices is done by the Puvrez pockets, but where the filtered liquid is immediately run into the *triple effect*, generally pass their sirups through bone filters. It is maintained the decolorizing effect of these operations has been satisfactory, but such sirups contained more impurities than was desirable.

We note some factories where *boneblack* is entirely suppressed, and Puvrez filters alone used. It is said that the suppression in no way influences the quality of the sugar nor its yield. Many refiners assert that the brown sugars of the first strike tested higher than those obtained by the ordinary method. M. Pellet has many explanations to offer respecting this subject, which we may discuss hereafter. One evident advantage of the pocket filtration is, that it requires little room, and the space needed for bone filters can be advantageously utilized. At M. Mercier's factory, Bresles, the actual saving per ton from the suppression of boneblack was as follows: Boneblack 5 cents, labor 1 cent, coke 2 cents, sugar,* etc., 1 cent; total 9 cents. If the repairs of the bone kiln for revivification are included, the saving may be estimated at 10 cents, or $2,000 for 20,000 tons of beets worked. It is said that the working of the process at the above factory is perfect, and the resulting sugar equal to any obtained by use of boneblack. At Bresles the second sugars averaged 88 pounds for 26 gallons of sirup, and tested 88 to 90. It may be interesting to state, that in a few cases where the success of the Puvrez filtration did not equal expectations, several difficulties arose in the filtration of the sirups. M. Pellet considers the difficulties in these exceptional cases were due to the peculiar condition of the juices, and not to the system of filtration.—*Sugar Beet.*

* This represents the value of sugar retained by the boneblack.—ED.

[LUMBER TRADE JOURNAL.]

UTILIZATION OF SAWDUST.

WOOD, whether in the form of logs, slabs, or sawdust, contains 75 per cent. of its weight of volatile matter, the remainder being carbon. If this be subjected to destructive distillation in closed vessels, and the gases and vapors conducted through suitable pipes and cooled, the liquids condensed are found to be equal in weight to about 40 per cent. of the wood and to be composed of a mixture of pyroligneous acid, tar, and water, about 25 per cent. being left in the retort in the form of charcoal, the balance or 35 per cent. passing off as an uncondensable gas. The composition of this gas, which is inflammable, will be hereinafter noted. Before proceeding further, I beg to differ with some of the writers in the *Journal* in regard to the salability of pyroligneous acid and the various products derived therefrom. On the contrary, my experience is that there is very little demand for the various acetates derived from pyroligneous acid. But if these volatile products be decomposed and converted into a fixed gas and mixed with the gas necessarily produced, we have a product composing 75 per cent. of the wood, which supplies a constant want in every location, namely, light. In order to produce illuminating gas, wood in the form of sawdust is found to be better adapted than almost any other material, for reasons which will become obvious as we proceed. That wood can be used to produce illuminating gas will be seen by the following, taken from Ure's "Dictionary of Arts and Manufactures": "If pieces of wood be placed in a glass retort half filled with boiling quicksilver at a temperature of 660° F. (at which quicksilver boils), a black lustrous charcoal is left, and the gas evolved is composed of—

Carbonic acid	56·4 per cent.
Carbonic oxide	36·6 "
Light carbureted hydrogen	7·0 "
	100·0

If, however, the vapors and gases produced as above be heated to a considerably higher temperature, the volume of permanent gas is considerably augmented, while such an amount of hydrocarbons is produced as to render the gas actually richer in these constituents than coal gas. The illuminating value of the hydrocarbons was found to be one-half greater than an equal volume of olefiant gas. These observations prove that wood gas is indubitably entitled to rank among illuminating agents. The following analysis shows the composition of wood gas made on an manufacturing scale; No. 1 being sample before purification at the works of the Munich Railway; No. 2, after purification at the town of Bayreuth:

No. 1.

Hydrocarbons	6·91 %	equal to	9·74 %	olefiant gas.	
Light carbureted hydrogen	11·06 %	"	"	%	"
Hydrogen	15·07 %	"	"	%	"
Carbonic oxide	40·59 %	"	"	%	"
Carbonic acid	25·72 %	"	"	%	"
Nitrogen					
	99·35 %	"	"	%	"

No. 2.

Hydrocarbons	7·70 %	equal to	11·93 %	olefiant gas.	
Light carbureted hydrogen	9·45 %	"	"	%	"
Hydrogen	18·43 %	"	"	%	"
Carbonic oxide	61·79 %	"	"	%	"
Carbonic acid	2·21 %	"	"	%	"
Nitrogen	0·42 %	"	"	%	"
	100·00 %	"	"	%	"

"The gas is entirely free from all sulphur and ammonia compounds, and possesses, according to Liebig and Steinheil, an illuminating power greater than coal gas in proportion of 6 to 5."

While it is not new to produce illuminating gas from wood, the writer has been able to learn of but one other instance where advantage is taken of the finely divided state in which wood exists in the form of sawdust for manufacturing gas, and this seems to be of very recent date. Without discussing the merits and demerits of this process, we will proceed with a description of the apparatus and process which has been found to produce the maximum results at a minimum cost. The sawdust being fed into a hopper falls into a horizontal pipe provided with a piston working with an intermittent motion, which feeds the sawdust into a pan or retort set in a furnace. Into the interior of this retort are fitted rakes and scrapers attached to a shaft in the center. As the sawdust is fed through the horizontal pipe, which is crowded full to prevent the escape of gas, it falls into the retort and is spread and stirred upon the red hot bottom in a very thin layer by the rakes, which instantly drives off all of the volatile gases, and in the meantime the resultant charcoal is carried around to an opening in the bottom, where it drops into a suitable cooling chamber. Simultaneous with this operation more sawdust is being fed and spread upon the bottom as before. The gases and vapors are taken off through ascension pipes and conducted through the superheating chamber, where any condensable vapors are converted into incondensable gas. At this point a small amount of hydrocarbon vapor is injected, the whole being thoroughly mixed and converted into a fixed gas of high illuminating power. Oil at the rate of 2½ gallons per 1,000 cubic feet of wood gas was used, and a sample of the commercial gas tested by Mr. G. A. Hyde, engineer of the Cleveland Gas Light and Coke Company, and pronounced to have an illuminating power equal to 24 candles—the average illuminating power of the gas produced by his company being about 18 candles. One machine will produce over 117,000 cubic feet of gas and 3,800 lb. of charcoal from 19,176 lb. of sawdust in 24 hours. To produce this amount of coal gas would require 45 ordinary coal-gas-retorts using 27,000 lb. of coal. Aside from the cheapness with which gas can be produced as compared with coal-gas, there are many other advantages which will not admit of discussion at this time.

The charcoal can be used in the manufacture of gunpower and for many other purposes. The feeding and removing charcoal being accomplished automatically, the only labor required is that of firing, which can be accomplished by one man.

Further information can be obtained by addressing the writer, J. E. Bickwell, at 420 Case Avenue, Cleveland, Ohio.

ZINCO-STARCH VASELINE PASTE.

THIS is a preparation for ointment suggested by Mr. Oscar Lassar, and is directed to be made by slowly triturating vaseline with equal parts of zinc oxide and starch. This makes a snow-white paste that will keep perfectly, and is adapted to serve as a vehicle for every sort of medicament.

This preparation has the following advantages over ointments: It does not melt at the ordinary temperature of the skin. It may be applied on very circumscribed places, and adheres without bandages to all parts of the body, but can also be used with bandages. The face, the extremities, the scrotum, and other places not easily treated with the usual ointments can be covered with this preparation so as to permanently exclude the air without any inconvenience.

This paste never irritates the skin. Patients that are afflicted with unpleasant symptoms on using all other salves, bear this perfectly. Its chief advantage is its porosity. While all fats, and substances physically similar to them, prevent the passage of water and prevent the coagulation of lymph and formation of scabs, this paste has just the opposite effect. By its use it becomes possible to attain the advantage of a cleanly and protective treatment for wounds, where the use of antiseptic bandages would be inadmissible.

Salicylic acid must be considered as an actual specific against eczema. It has proved of particular value when applied with vaseline or zinc vaseline in the proportion of 2 per cent. A smaller quantity does no good, and a large dose sometimes proves irritating. In the common infantile eczema of the head, rapid and permanent results have been obtained by rubbing the part two or three times a day, after it is well cleansed, with salicylic vaseline containing a little tincture of benzoin, as follows:

Salicylic acid	1 part.
Tinct. of benzoin	2 "
Vaseline	50 "

For softening the crusts and cleansing the scalp, it is well to use a 2 per cent. solution of salicylic oleate, which is very easily prepared, since salicylic acid is very soluble in all non-drying oils, and in the glycerides of oleic acid.

In all places where it is inconvenient to apply a soft and easily fusible salve like the salicylic vaseline, where a firm bandage or a drying action is required, the acid may be rubbed up with the oxide of zinc and starch as follows:

Salicylic acid	2 parts.
Vaseline	50 "
Zinc oxide	25 "
Starch	25 "

Mix thoroughly to a smooth ointment. A thick layer of this is applied to the sore and moist spots, so as to exclude the air, and this can be covered with a thin layer of cotton.

For eczema, salicylic ointment is almost always effective, and hence may be recommended as a convenient, cleanly, and efficient remedy for slight or severe wounds.—*Monthly Magazine.*

APPARATUS FOR INSTANTANEOUS PHOTOGRAPHY.

WITH ordinary photographic apparatus it is necessary to begin by focusing upon the object that one desires to photograph, and to afterward remove the ground glass and substitute for it a frame containing the sensitized plate. After this, the latter is uncovered and the cap is taken from the objective. It goes without saying that if the object to be photographed were an animal in motion, it would have been out of sight long before everything was arranged to take its image upon the sensitized plate. This difficulty has been surmounted in three ways. One consists in the use of objectives that give an equal sharpness with objects situated in very different planes, and that do not require focusing. The second way of getting around the difficulty is that adopted by Messrs. Muybridge and Marey, and consists in setting up the apparatus in advance, focusing it upon a certain point, and then causing the animal to pass before it.

The third method is one whose principle was made known some time ago, and which consists in using a very portable apparatus formed of two symmetrical and interdependent chambers, with a pair of identical objectives, one of which serves for focusing and the other for obtaining the image.

The majority of the apparatus of this kind that have hitherto been invented give exceedingly small images, that are of not much practical account.

Prof. Hermann Fol has invented an apparatus on this principle which is a great improvement upon all other portable devices of the kind in use, and which he terms a "photographic repeating gun." This is placed against the shoulder like an ordinary rifle, and is thus given sufficient stability to make the images very sharp. The image, although it utilizes only the central part of what the objective is capable of covering, measures 9 by 12 centimeters. The apparatus contains 11 plates, which may be successively exposed within short intervals, without any other manipulation than that of raising the shutter and inclining the whole thing alternately in one direction and the other. Finally, it folds up in such a way as to make it convenient for carriage.

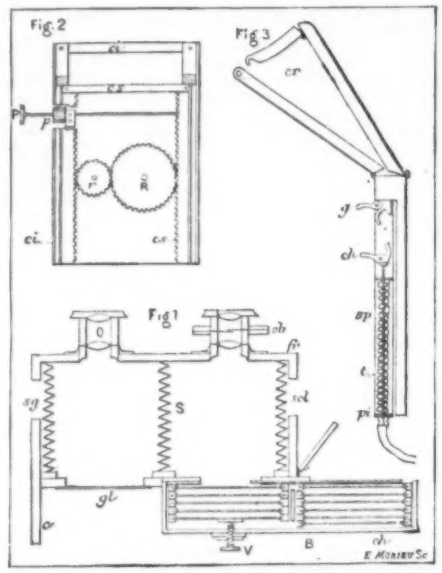
The objectives are Steinheil's "antiplanets," 2½ centimeters in diameter, of 14½ centimeters focus, and capable of covering a plate 33 centimeters square. Their luminous power is considerable.

The shutter is a spring one, operated pneumatically, and consists of two metallic disks, each containing an aperture and passing in opposite directions between the two sets of lenses of the objective at the place where the diaphragm is usually situated. It gives exposures that may be varied at will from $\frac{1}{10}$ to $\frac{1}{1000}$ of a second.

The camera is divided into two spaces by a partition (Fig. 1, S) which is lightproof. The folding sides of the camera are formed of strips of cardboard, one thickness of black taffety, and kid skin. The left side (Fig. 1, *s g*) forms a chamber which is designed to allow the objective to the left, *o*, to form an image upon the ground glass, *g l*. The right side, *s d*, circumscribes the space in which the objective that carries the shutter, *o b*, forms an image upon a sensitized plate contained in the box, B.

The two objectives are carried by a wooden front, *f r*. A large frame, *c*, carries the ground glass and plate box, and, at the same time, serves as a point of attachment for the folding sides. Adjustment is effected by moving the front, *f*, toward or away from the frame, *c*, by a mechanism that we shall describe further along. The plate box is sufficiently spacious to hold twelve plates in two piles of six each. Each plate is fixed in a small wooden frame, provided at the back with a very thin piece of sheet iron, which intercepts the light between it and the following one.

The two piles of frames are separated from each other by an incomplete partition that leaves enough space here and there for one of the frames to slide from one pile to the other. If, then, this 12-frame box contains but 11 frames, an empty space remains, and it will always be possible, by inclining the box, to cause the eleventh frame to slide from one pile to the other. When a plate has been exposed, it is



FIGS. 1, 2, AND 3.—DETAILS OF FOL'S PHOTOGRAPHIC APPARATUS.

therefore only necessary to incline the apparatus toward the right to cause the plate to enter the compartment situated on that side. If, now, the apparatus be pointed so that the objectives face the ground, and afterward be inclined to the left, one of the plates to the right will slide on to the pile to the left. Before each exposure it is well to tighten the

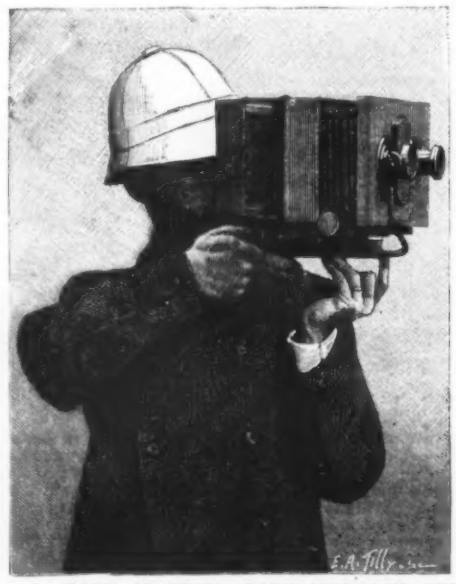


FIG. 4.—MODE OF USING FOL'S PHOTOGRAPHIC GUN.

screw, *v*, a little, in order to apply the foremost frame against the end of the box and give it exactly the same distance from the objective that the ground glass has. By repeating the same motions the 11 plates will be exposed in succession without any confusion being possible, and without there being any necessity of opening the box, or of

FIG. 5.—SPECIMEN OF A PHOTOGRAPH TAKEN WITH THE APPARATUS.

allowing light to pass at any other moment than that of the exposure.

When the exposure is at an end a metallic plate is pushed, and this separates the interior of the plate box from the chamber to the right. The box, being now closed on all sides, may be removed and placed entirely in the frame, *c*, which is closed by a small door. When the front end is applied to the frame the entire apparatus is reduced to a box, 13 x 16 x 24 centimeters in dimensions.

The focusing is effected by two metallic frames provided with racks (Fig. 2) that are placed beneath the apparatus—one of them carrying a front piece, *c i*, and the other, *c s*, sliding in a groove in the frame. These two frames are set in motion, one over the other, by a lateral button, P, at the end of a rod that carries two grooved cylinders, *p*. These grooves engage with the rack of the lateral pieces of the metallic frame, *c i*. The frame, *c s*, is set in motion by a horizontal wheel, R, which has a vertical axle that terminates beneath in a knob which is held in the left hand and serves to support the apparatus. It is only necessary to slightly turn the palm of this hand in one direction or the other to bring about a rapid motion of the frame, *c s*, and consequently of the entire front end with the objectives, through the intermedium of the large wheel, R (Fig. 2). A small wheel, *r*, serves for transmitting the motion of the large one to the opposite side of the frame, and to give it a parallel sliding motion free from any lateral displacement.

When in use the apparatus is affixed to a frame (Fig. 3) which is like a gun-stock in form, but which consists of four hinged pieces that permit of its being folded up. The front part contains a tube (Fig. 3, *t*) in which slides a piston, *p i*, actuated by a spiral spring, *s p*. This spring, upon uncoiling, drives the piston suddenly forward and produces a compression of the air which is transmitted, through the rubber tube, *c a*, to the shutter, and unfastens it. In order to tighten the spring up it is only necessary to draw back the piece, *c h*, until it hooks itself to the trigger, *g*. A pressure of the finger upon the latter is sufficient to set the shutter free.

The mode of using the apparatus is as follows: The plate box being inserted, the shutter raised, the stock placed against the shoulder, and the spring tightened, it suffices to turn the apparatus toward the object to be photographed, and to examine its image upon the ground glass (Fig. 4). A slight movement of the left hand effects the focusing, while the index of the right hand determines the amount of exposure. It is only necessary, then, to incline the apparatus successively in two directions to cause another sensitized plate to succeed the one that has just been exposed; and, when the spring has again been tautened, one can proceed to another exposure.

With the plates now in market there may be obtained in open air, in fine weather, in summer and in the middle of the day, very excellent negatives. Under other circumstances so rapid exposures are insufficient to impress the plate to the desired degree for a good negative.

Fig. 5 is reproduced from an instantaneous photograph taken with this apparatus.—*La Nature.*

GROWTH OF ELECTRICAL SCIENCE.

ELECTRICAL science, historically considered, is now the most interesting of the several branches of human knowledge that have been reduced to system entitled to the name of science. It is made so by reason of its great practical value, its recent origin, and because the discoveries in this field have been made in the printing age. So few, indeed, are the observed facts and known laws of electrical science that it would be possible to condense all that are essential to a practical knowledge of every present application of electricity into a pocket hand-book. And yet, notwithstanding this, the science, practically applied, is one of the most useful agencies of modern civilization.

The first electrical discovery was that of frictional electricity, by Thales, of Miletus, six hundred years before Christ. For many hundreds of years little more was known than that by rubbing amber or glass with silk or wool or fur, they had imparted to them the faculty of attracting light bodies. The properties of natural magnets were also observed, and their relation to electrical phenomena was suspected; but even this had to wait for proof until quite recent times. The invention of a frictional electrical machine was a comparatively simple matter, based upon the desire to have a convenient means of rubbing glass to produce electric currents. It involved no new electrical discovery, but afforded a convenient means of experimenting. Up to the middle of the seventeenth century little more had been learned about electricity than this solitary fact, that it could be produced by the friction of certain bodies. Then Otto de Guericke for the first time, so far as is known, observed the electric spark, and a century later our own Franklin demonstrated the identity of lighting and electricity, and thus accounted for the spark. In the mean time, however, a few other facts had been observed. In 1729 Stephen Grey had discovered electric induction, and that there was a decided difference in the conductivity of different materials. This difference is so great that it led to the division of bodies into conductors and insulators, although more exact science now recognizes only differences in *degree* of conductivity. About the middle of the eighteenth century Von Kleist, of Cammen, and Cunæus, of Leyden, discovered what is now known as the Leyden jar. Franklin was the first to offer an explanation of this and similar apparatus. Following this came the experiments of Franklin and others, whereby the discharge from Leyden jars was sent through wires to a distance, and thence arose the first efforts to devise a system of telegraphy. For the next fifty years scientific men kept on experimenting with frictional electricity, but learned very little that was useful, and practically failed in all attempts to harness it for useful work. The properties of frictional or statical electricity are entirely different from those of voltaic or dynamical electricity, and make it unsuitable for practical use in telegraphy, electric lighting, motion for power, or other modern applications. But it is so startling in its effects that it is well suited for electrical illustration, and, until recently, was almost exclusively employed in lecture illustrations.

The great discovery from which modern electrical science originates was made by the Italian philosophers Galvani and Volta. This was, that electricity could be developed by chemical decomposition. It was announced in the year 1800 in a letter from Volta to Sir Joseph Banks. A Pennsylvanian, Prof. Coxe, was one of the first to turn voltaic electricity to practical use, he having proposed an electric telegraph system based upon the decomposition of water by the current, about the same time that Sommering suggested a similar system. From this time forward the advances in observation of phenomena, their practical application, and theories explaining them were very rapid. In 1820 Oersted discovered that an electric current would deflect a magnetic needle, and Arago and Davy that a piece of iron, surrounded by a spiral wire through which a galvanic current passed, would become magnetic.

Few and simple as these observed facts appear to us now, they had only been reached after many years of searching and experiment, and they form the basis of the telegraphic systems of the world. But enough was not yet known to make telegraphy possible; and just here we may see how theory and observation work hand in hand, sometimes one leading and sometimes the other. Ampere explained the discoveries of Arago and Davy by the really remarkable hypothesis for that time, that magnetism is the result of the circulation of currents of electricity at right angles to the axes of the poles of the magnet. Five years more elapsed before Sturgeon made practical use of this hypothesis by constructing the first electromagnet, which is an essential part of nearly all electrical contrivances of to-day. An attempt was made to use Sturgeon's electromagnet for telegraphic purposes, but it failed, and Prof. Barlow proved to the satisfaction of himself and other people that an electromagnetic telegraph was impossible. This theoretical suggestion was made about one one year before Joseph Henry, then a young man, set up his electro-magnetic telegraph at Albany and made the counter demonstration, in both theory and practice, that such a system of telegraphy *was* possible, and was indeed an accomplished fact. Prof. Henry's services in this respect have never received the acknowledgment they deserved, except from scientists. He was a great pioneer in the investigating field, the inventor of the compound electromagnet, by which the magnetic power was greatly multiplied, and of many of the devices whereby more "practical" and self-seeking men afterward perfected and introduced electro-magnet telegraphy. But by this time scientists in all parts of the world were busy with electrical experiments, and discoveries and inventions followed thick and fast. Some time prior to 1837 Steinheil had made the important discovery that a return wire was not necessary to complete the circuit, but that this could be made through the earth. Everything necessary to the practical application of electricity to telegraph had now been discovered, and it only awaited sufficient mechanical skill to apply known principles. Almost simultaneously Morse in America, Wheatstone and Cooke in England, and Steinheil in Germany made the required application, and commercial telegraph lines were established. Only a few years after the construction of the first telegraph lines, Page discovered that a musical sound accompanied the disturbance of the magnetic forces in a bar when suspended so as to give acoustic vibrations. This was the beginning of the telephone, as subsequently developed by Reiss, Gray, Bell, and others. But while practical men were making use of the little knowledge they had obtained, and while such scientists as Faraday and Henry were helping them by researches and experiments, the German mathematicians were also at work measuring the forces and resistances and formulating the laws which govern the development and transmission of electrical energy. The most famous of these investigators was the German Ohm, whose name is transmitted to posterity by the grateful electricians who are guided by the laws he discovered, and which tell them what proportions to give to the parts of their apparatus.

Coincident with the progress of the telegraph the galvanic battery was brought into large use in the work of electroplating.

An entirely different field of electrical science, and the one wherein electric lights have been developed, is of still more recent origin than the voltaic battery and the electro-magnet, which form the basis of the telegraph and telephone systems. Faraday, a purely scientific investigator, laid the foundation of all the inventions and discoveries in this field only a little more than fifty years ago. Alternately experimenting and deducing hypotheses from observed facts, he discovered that by the forced motion of a magnet electric currents could be produced. Faraday's discoveries led to the invention of magneto-electric machines, which produce dynamic-electricity at much less cost than voltaic batteries, and make electric lighting possible.

From this brief review of some of the principal points in the history of electrical science, it will readily be seen that a more detailed study would disclose almost the processes of thought whereby knowledge has been advanced step by step. It also shows distinctly how slow and uncertain the first steps are, how a simple obstacle sometimes delays experimenters and inventors for years or centuries, and how, as knowledge broadens, the way becomes clearer and the step more firm, until at last, though everything is not known, enough knowledge has been gathered to make this great natural force an obedient servant of man. How vast the product is even now in the infancy of the science, is what is to be shown in our great Electrical Exhibition by the Franklin Institute next month.—*Phila. Ledger.*

EXPERIMENTS ON ELECTRIC LIGHTING, AT BREST, FOR THE DEFENSE OF PASSES.

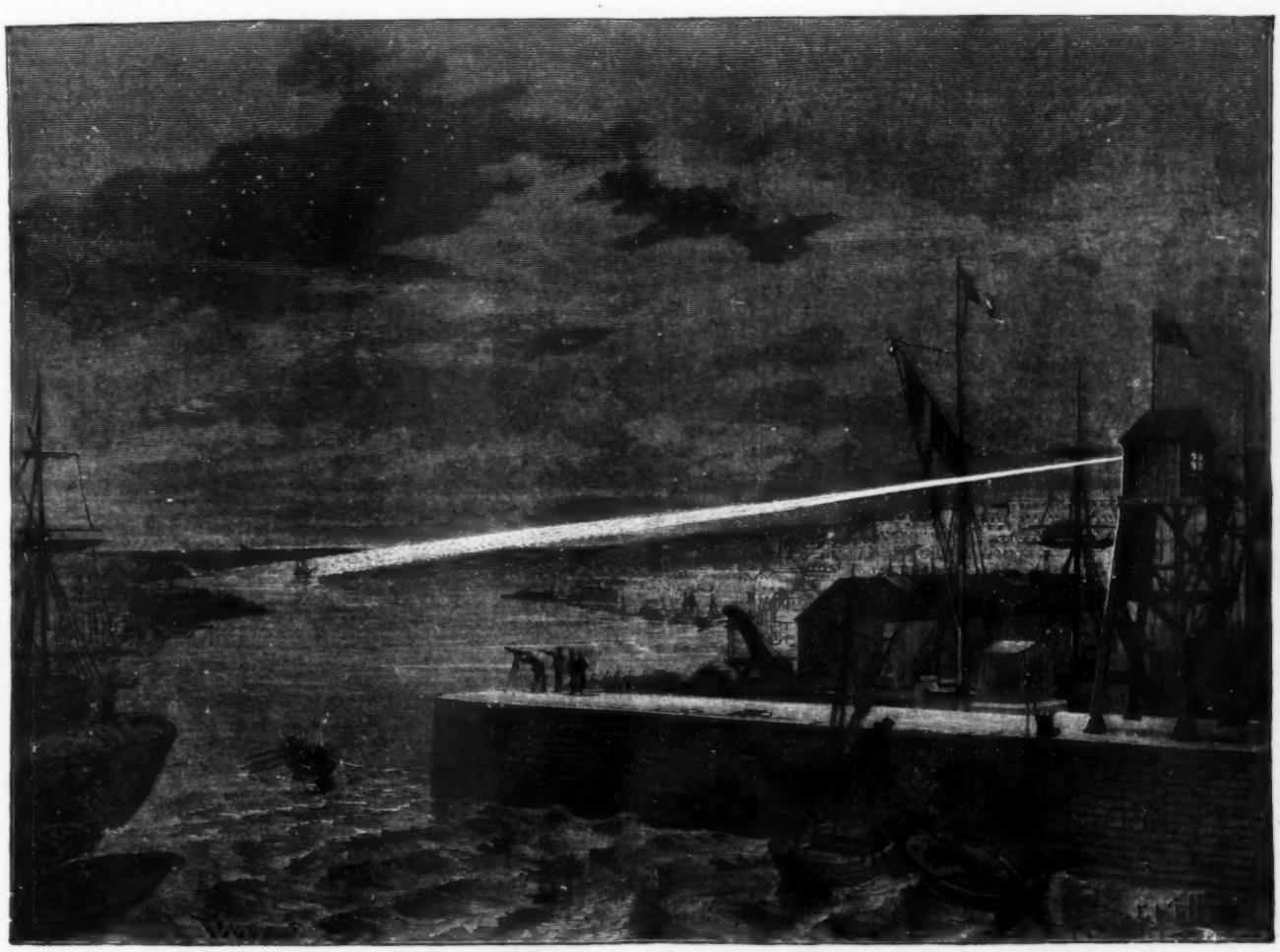
THE French navy is making experiments of a most varied character upon the application of the electric light, both on ship board and on the coast.

The accompanying engraving, which gives a perspective view of the port of Brest, on the channel side, during nighttime, represents the most interesting moment of an experiment performed by the officers of the navy with a view to exploring the entrance to the port by means of powerful electric lamps located upon the jetty, and so arranged that the light could be projected in all directions. The experiment concerned the watching of a supposed hostile vessel which had been sighted in time of war, and which was endeavoring to stealthily cross the pass of Brest. The Laborieux, a tow-boat of the port, representing the enemy, was to try to force the entrance of the wide and deep roadway (an operation that a fleet might attempt in war times), and the question was to see whether, by means of powerful electric apparatus placed on land, the darkness could be penetrated at a distance so as to show the foe in sufficient time to allow the defense to turn its guns upon him, or to attack him with torpedoes. The lamp, which is shown upon its support to the right of the engraving, was of a luminous intensity of 4,000 Carcel burners, and was placed at the entrance to the port. Proceedings were begun by directing the luminous rays toward the vessels that were anchored in the port, and these were so perfectly illuminated that there would have been nothing to prevent the battery cannon from being aimed at them.

At this moment the Laborieux sailed toward the port, according to instructions received, but was discovered in the middle of the neck, toward Mingan rock. (In the engraving, the vessel is seen in the center of the luminous projection which is being sent from land by the officers charged with the defense.) The enemy changed position several times, performed his evolutions quickly, and endeavored to get out of the light which was rendering his bold attempt abortive, and which was making his situation most critical, because of the converging fire that the electric light permitted of aiming at him; but the luminous rays that were concentrated upon him followed him in all his movements, and rendered him the more apparent in that all was in darkness outside of the fascicle of light.

Two torpedo boats, which had been stationed near land, could easily have boarded him then, or launched their torpedoes without being perceived, inasmuch as in practice an enemy, in order to force a pass by surprise, does not use his electric light as he would upon the open sea for protecting himself against the terrible attacks of torpedo-boats. In fact, in such a case a light on board would reveal the presence of the vessel to the defenders of the port, and, for this reason, it would be impossible to sweep the horizon in order to determine whether any torpedo boats were around.

This Brest experiment, then, was a perfect success, and proved that electric lamps of sufficient power will show any attempt that is made to cross the widest pass during nighttime.—*La Lumiere Electrique.*



ELECTRIC LIGHT EXPERIMENTS AT THE PORT OF BREST.

ON ELECTRICITY AND ITS PRESENT APPLICATIONS.*

By W. FRASER, A.M., M.R.C.S. Eng.

IT is right to mention that this paper—or rather the nucleus of it—has been already read to a medical society and to an ecclesiastical guild, a statement you will readily believe from some passages in it—*entrées*, I may say, in the entertainment, specially provided for the tastes of these guests. But now that I have ventured, though with fear and misgiving, to bring it before an audience of philosophers, who are quite competent to deal with the subject, I have added a few *pieces de resistance*, which may help to secure your attention, and afford something to eat up and masticate, whether you think fit to swallow and assimilate them or not.

An apology may be expected for my bringing before a medical society a subject not strictly medical, and I quite admit the validity of the objection. But although electricity has never been so far professionally recognized as to have a place in the Pharmacopœia, we all know that it has long been employed both as a diagnostic and therapeutic agent, and that of late it has proved a valuable method of treatment (particularly in nervous diseases) in the hands of several eminent London physician.

We know, too, that in the present period of popular excitement it is beginning to take a prominent place in the field of quackery, with plausible and high-sounding pretensions, and in such a way as will probably prove an obstacle to its employment in legitimate medicine. I do not think, however, that legitimate medicine will suffer much by the loss, for whatsoever may be the influence that electricity has in regard to the functions of the human body—and it is undoubtedly great—this influence or these influences can best be brought into action through the judicious use of the old and ordinary means, whether pharmaceutic or pyschologic—acting, as these do, through the nervous or electric functions of the body itself—which the profession has long been accustomed to employ.

I do not, therefore, intend to treat the subject specially in its medical aspect, and shall, without further apology, bring it before you in the way that has happened to approve itself to me. You will not, I hope, take offense if I ask you, during the reading of the paper, to fancy yourselves in the position of a group of children, or of untutored natives of the East listening to one of their own story tellers, while he tries to please them for an hour, and to convey to them some practical and useful instruction by the scenes and sketches he places before their imagination.

When the Allwise, Omnipotent, and Eternal created and organized this world, he placed in it certain genii, immortal but soulless spirits—His slaves or ministers, as they might be called—to carry out His will in its government, and in the purposes He had in view in its creation. One of the

* Read at the Aberdeen Philosophical Society, February 5, 1884.—*Journal of Science.*

most powerful of these—the genie of the mystic fire, Electron—is invisible to the human eye, and unrecognizable by the ordinary human senses, except upon rare occasions, or when subjected to the spell of a skilled magician.

It is difficult to give a correct protrait and dimensions of this great spirit; but it may be said that, while his head reaches far above the clouds, and his feet go down into the bowels of the earth, and traverse them more freely than a bird can fly through the air, he can also enter into the smallest and invisible cell that forms part of the material of the globe. In truth he performs an important part in almost all the operations going on in the world, whether great or small; but so quietly and gently does he work that his presence is never known or suspected, except on the occurrence of something calculated to rouse him to anger or opposition.

The power and immensity of this genie may be in some degree comprehended when it is stated that the tremendous roar of his voice, the dazzling brightness of the flash of his eye, the inconceivable rapidity of his movements, and the irresistible force of his strength are such that in respect to them there is no terrestrial being that can be compared with him. When careering with his full force, if any obstacle should interrupt his progress or tend to circumscribe his liberty, he will in a moment burst the strongest barriers in his way, shattering and destroying them by streams of fire which he launches forth, accompanied with such appalling and tremendous bellowings as seem to make the earth to tremble. Such behavior on his part naturally inspires mankind with terror and awe, and it has had the effect, in past times, of deterring them from cultivating his acquaintance or friendship. Indeed, until very rencent times, they looked upon him more in the light of God's minister of punishment and destruction than as the friendly and beneficent, though powerful, being they are now beginning to discover him to be.

A wise man of America, named Benjamin, who, more than a hundred years ago, was among the first who had the courage, sagacity, and tact to enter into close and friendly relations with him, by a careful study of his character and habits, succeeded in making an arrangement by which—in consideration of an easy and free passage being provided for him between his favorite resting-place under the ground and the upper air—he gave promise for the future to refrain from an old and destructive practice he had been in the habit of indulging in—that of toppling over and destroying towers, chimneys, and other lofty buildings that chanced to attract his notice. And the fact of his having honorably kept this promise has led to a further study of his powers and peculiarities, and to the cultivation of more friendly relations with him than had been done before.

He is constantly hovering and brooding over the earth, mantling and pillowing himself in the clouds; sometimes marshaling them in hostile array against each other, traveling with them in their movements, and descending with them in union with the rain, to refresh and fructify the ground; ascending, also, as well as descending, by secret and imperceptible movements, in the fulfillment of the innumerable services which God has ordained him to perform. Though such is the usual and gentle manner of his transition between earth and sky, yet it sometimes happens, when he finds himself unduly confined on the one side, that he will make a sudden and irresistible bound to the other, overturning, blasting, and destroying whatever may stand in his way, and emitting a roar of thunder surpassing in awe-inspiring grandeur the cries of all the wild beasts of the forest blended together.

By following in the wake of the American *savant*, electricians have succeeded in greatly mitigating—in many cases in entirely averting—the calamitous effects of such occurrences. Knowing the partiality he has for certain of the family of the metals, and the willingness with which he will accept of their guidance and means of transport, they have constructed roads (literally rods) of iron, copper, or bronze between the earth and the highest points of the chimneys and lofty buildings that were wont to be injured by him. These rods or tubes are provided with incorrodible points—often trifurcate—at their upper extremity, and the genie gives a very decided preference to this kind of passage, both by way of exit and entrance, and when making use of it he is quietly led either downward or upward, whichever way he requires to go, till all danger of a sudden outburst is past.

For many ages mankind were almost unaware of the presence among them of this powerful spirit; nor did they know that he was unceasingly employed in their service; and much less were they able to summon him at will to appear visibly and tangibly before them, to exhibit some of his wonderful powers. When at last they did succeed in this, the utmost wonder and interest were excited by the display, although the form it took was what might at present be looked upon as mere childish tricks compared with the stupendous and beneficent powers of which he is now proved to be possessed. His favorite resting-place of retirement is, as I have said, deep in the interior of the world, from which, however, he is continually emerging and gliding to and fro through the earth and the air, doing an infinite variety of useful and beneficent work; after accomplishing which he, by the law of his existence, quietly retires to the place of his concealment. But if anything should stand in his way, or resist his passage, woe be to that person or thing! Personal injury, or even destruction or death, is sure to be the result.

While thus pent up, miles deep in the interior of the earth, and finding no ready means of escape, he will sometimes break the bonds of his prison and force a passage or place of exit for himself, and in doing so shake the earth for miles around, leaving great rents in it, overturning buildings, destroying millions' worth of property and thousands of lives. This heavy charge, at all events, has been brought against Electron as one of the various hypotheses that have been suggested in explanation of earthquakes. But though he may in some degree be connected with these phenomena, there is far from sufficient proof that he is the principal or sole agent, and in the Court of Science the verdict could not be more than "Not proven." But *if he be* the great cause of these terrible convulsions, might it not be possible that the happy invention of Franklin, which has averted so many of the disastrous effects of aerial and surface lightning, could also, in some way, be applied to the deep underground storms (if indeed the depth were not too great) which are supposed to be connected with earthquakes?

Colonel Arthur Parnell, writing on the subject in the *Journal of Science* for December, 1883, adduces some passages from the Apocalypse to show that the inspired writer of that book considered lightnings, thunders, and earthquakes as being results of one and the same agency, though perhaps not of much scientific value as bearing on the question; these passages are sufficiently interesting and apposite to be requoted:

"I saw the seven angels which stood before God, and to them were given seven trumpets. And another angel came and stood at the altar, having a golden censer; and there was given unto him much incense, that he should offer it with the prayers of all Saints upon the golden altar which was before the throne. And the smoke of the incense, which came with the prayers of the Saints, ascended up before God out of the angel's hand. And the angel took the censer and filled it with fire of the altar, and cast it into the earth; and there were voices, and thunderings, and lightnings, and an earthquake" (Rev. viii., 2–5). Again, "The seventh angel sounded, . . . and the temple of God was opened in heaven, and there was seen in His temple the work of His testament; and there were lightnings, and voices and thunderings, and an earthquake and great hail" (Rev. xi., 19). And again, "The seventh angel poured out his vial into the air; and there came a great voice out of the temple of heaven from the throne, saying, It is done. And there were voices and thunders and lightnings; and there was a great earthquake, such as was not since men were upon the earth, so mighty an earthquake and so great" (Rev. xvi., 17, 18).

Notwithstanding the amount of work he is known to perform, Electron is also fond of dancing, and his favorite place for enjoying this pastime is in the neighborhood of and around the poles of the earth. There, in a bright frosty evening, mortals may often get glimpses of his holiday garments fluttering and coruscating in all the beautiful hues of the rainbow, mysteriously vanishing and reappearing as he disports in the fantastic evolutions of his mystic dance.

It is not to be understood, from the repeated references to the favorite resting-place of Electron as being in the earth, that the sea receives less of his regard than the dry land. On the contrary, there is every probability that the sea is even more abundantly and unvaryingly his place of abode than the land. Water is far more congenial to him than land, and in it he can stretch out and rest himself more compiacently than on land. His passage between the clouds and the sea will of course give rise to the usual phenomena attending similar transitions on earth, but there is nothing in the ocean's boundless expanse of waters to intercept his movements or rouse him to anger and violence. I believe that he is abundantly diffused through its whole extent down to its utmost depths, and that he is the means of imparting life and vigor, and exuberant—almost superabundant—fertility to the multifarious and innumerable creatures that have their habitation there. The very atmosphere of the sea is impregnated by him to a greater extent than that of the land. The superambient air is ozonized or charged with his influence, and thus rendered, as is well known, salubrious and life-giving to invalids, after the ordinary resources of medicine have failed.

In illustration of these statements it may be allowable to refer to the significant fact that while there are at least a dozen fishes that are provided with electrical organs, and capable of using them both for sustentation and defense, there are no land animals known to be so endowed. The fishes referred to "belong to three widely different groups—namely, rays, eels, and sheath fishes—which would seem to indicate that electric organs have originated independently in each group. The electric eel of South American rivers is the most powerful of these creatures, growing to a length of six feet, and provided with a pair of batteries containing hundreds of minute cells, copiously supplied with nerves, and capable of sending forth shocks which will paralyze the largest animals."*

While it is only within the last few years that man has been able to make use of electricity as a weapon of war against his enemies, these creatures have for many thousands of years—probably before man appeared upon earth—been applying their electrical batteries to the art of capturing their prey—electric batteries, be it observed, which "behave in exactly the same manner as those constructed artificially, rendering the needle magnetic, decomposing chemical compounds, and emitting the spark."

For the capture and taming of wild and vicious animals, might we not be able to take a hint from these facts in natural history?

Electron exerts a mysterious but powerful influence on the sensations of living—probably all living—creatures. The behavior of many of the lower animals gives well understood indications and warnings of changes of weather to be expected from his approach or his movements. In the human body, also, he can by his presence induce the most pleasurable and salubrious feelings, or sensations of the most disagreeable nature.

There are various ways in which the magi at first succeeded in conjuring this potent spirit, making him give indications of his presence. Sometimes this was done by making a grateful and rapid friction with a metallic or other substance of which he is known to be fond, through the medium or interposition of a suitable receptacle placed in communication or *en rapport* with the earth where he resides. The result is that he comes gradually into the vessel or trap, and indicates his presence by a crackling noise and the emission of sparks, just as is done by him when the back of a cat is treated in a similar manner. At other times he was tempted to make his appearance by a dish of metals stewed in an acid, for which he has a well known predilection.

But now, by God's permission, the power has been given to the wise men of various countries—more especially those of Britain, France, Germany, Italy, Russia, and America—to secure, bind, and imprison him in a leaden vessel or casket, and to seal it with the seal of Solomon the Wise, so that he can be kept there as the submissive slave of his captor, carried to a distance, and when released forced to perform whatever work may be appointed him to do. In this way he can, under proper superintendence, be made to perform the work of a domestic slave or servant, in sewing, washing, etc., and even in lying on the watch and sounding an alarm in the event of robbery or of fire. He can also be made use of as the motive power of vehicles and machinery of all kinds. In short, he can be made to perform any kind of mechanical labor which does not require the direct exertion of mind and intelligence—gifts which God has bestowed on man alone. In view of the grandeur and immensity of his attributes, we might almost think that the following sublime language of St. John, in the Apocalypse, is intended to portray him!

Rev. x., i.—"And I saw another mighty angel come down from heaven, clothed with a cloud, and a rainbow was upon his head, and his face was as it were the sun, and his feet as pillars of fire; and he had in his hand a little book open: and he set his right foot upon the sea, and his left foot on the earth, and cried with a loud voice as when a lion roareth: and when he cried, seven thunders uttered their voices. . . . And the voice which I had heard from heaven spake unto me again, and said, Go and take the little book which is in the hand of the angel which standeth upon the sea and the earth. And I went unto the angel and said unto him, Give me the little book; and he said unto me, Take it, and eat it up, and it shall make thy belly bitter, but it shall be in thy mouth sweet as honey. And he said unto me, Thou must prophesy again before many peoples and nations and tongues and kings."

The variety of designations that are given to Electron by scientists is apt to perplex those that are not familiar with the subject. These have been given according to the sources from which he can be educed, the forms he appears in, and the functions he performs—such as positive and negative; static and free, Voltaic, Franklinic, and Faradaic, animal, frictional, and magnetic; and many besides. But these names, like the roll of names often given to potentates of the world, all belong only to the *one* great genie who is the subject of our present discourse.

The motions which God has given to the great oblate globe of the earth must, we should expect, cause relative motions on the part of such a mobile and ethereal substance (if substance it can be called) as that of this great genie. We do not know the natural laws by which spirits are governed, but, speculating on their analogy to those which apply to the rarest of fluids and gases that we are acquainted with, we may to some extent be assisted to understand how such a spirit would comport itself in the world; though even the laws of acoustics or of hydrodynamics cannot properly be considered as altogether applicable to so immaterial and imponderable a being as Electron.

The natural effect produced on these fluids by the rotation of the earth would be centrifugal at the meridional circumference and centripetal at the poles. In the case of the Electric spirit, supposing, as some with reason think, that it *has* the slightest amount of gravity, the rotary motion of the earth would, at both ends of its axis, tend to draw it into the interior, which it would penetrate and traverse as easily as if it were a hollow sphere, and, the motion of the globe being greatest at its equatorial circumference, the spirit would find its way there; it would issue forth (refreshed and invigorated by his passage through the central fire of the earth), imparting warmth and fertility to the tropical regions, though often giving indications of his superabundant presence by frolicksome outbursts, which are sometimes attended by disastrous consequences. And thence he would become diffused through and over the atmosphere, and so would find his way back to the Poles there to be again absorbed, and to enter on what might be called his normal circuit of the earth. Thus the earth sustains the part of a vast storehouse, continually receiving detachments from this spirit of the universe by its great polar and other entrances, and as continually giving forth supplies by even more numberless exits.

Though one of the principal agents in carrying out the laws by which God governs the world, Electron is himself subject only to such laws as are adapted to his constitution and the purposes for which he was created; and the Supreme Governor has given permission to man, when he ascertains and pays deference to those laws, to make his own use, to a limited extent, of the powers and the service of this great spirit.

This powerful and ubiquitous genie has close relations with all animate and inanimate things in the world. Between him and some of them there is a much greater attachment than with others, as, for instance, in the case of the metal iron, that greatest friend and servant of man of all the metallic race.

The further our researches and observations have yet been carried in this direction the more they tend to confirm the belief, inspired also by the study of other branches of natural science, that the Almighty wisdom and power operate by means at once the most uniform and simple in their individual and atomic manifestations, and unspeakably efficient, grand, and beautiful in their combined and predestinated outcome. The universe itself consists of an infinite number of globes or spheres, in constant, regular, and multiplex motion, and having certain sympathetic influences and relations with each other through means of a property called gravitation. The ultimate or minutest division which we are capable of making of matter, as well as the most careful study of its properties, leads to the same conclusion as to its constitution, namely, that its atoms or ultimate components are also spheres either in motion or capable of being put in motion, and having opposite poles and attractive powers for other atoms, whether of the same or of different species. But instead of being called gravitation the attractive force of these atoms is known as chemical action, though it is believed by *savants* to be the effect of some special properties conferred upon them by Electron. And it is—beyond all his other qualities—by his power of imparting and governing molecular attractive forces that such all-important results are produced throughout the world as prove the Genie Electron to be the most powerful and omnipresent of God's ministers on earth.

When the particles of different kinds of matter are free to mingle with each other—which by means of heat, air, water, and other media they can be made to do—he can make them change their arrangements, and can subject them to such magical transformations that they become entirely new substances, with appearance and qualities essentially different from their previous condition. That *he* is the immediate agent in effecting this may be fairly inferred from the analogous work he is known to do on a larger and visible scale, as well as on other reliable scientific grounds.

We can easily see the results and the accompaniments of this great spirit's working in many of the phenomena of the world, but no man has ever yet seen him *actually* at work or discovered his practice *modus operandi*. When God made himself known to Elijah it was not in the tempest, the earthquake, or the fire, but in the still small voice in the desert. And so it is that the silent and secluded chamber of the scientist is also the most congenial and favored place for contemplating the working of His great minister on the earth. By long continued transformations of the kind described he has changed, and is still changing, the aspect and condition of the surface of the world, and it is by a knowledge of these powers, and by the wisdom to take advantage of them, that most important results both to the initiated scientists, and, through them, to the world at large, are to be obtained. Out of three or four elementary substances, for instance, he can, under propitious circumstances, form a vast number of things, of very diverse qualities, adapted to enrich, sustain, and beautify the world and its inhabitants. Like a skillful general, or a clever master of ceremonies, he can place his subjects (small and invisible to us as they individually are) in all manner of composite groups, and in every variety of arrangement, and by his signal of command can make innumerable hosts of them embrace and coalesce, so as to constitute new masses, possessed of a character and qualities very different from those they had before, as well as from some other groups composed of the same elements. By operating through means of the different degrees of mutual affection between these atoms and their chief, and for each

* *Longman's Magazine* for March, p. 529.

other, he can bring about a sharp and rapid conflict among them, leading to their separation and rearrangement, so as to form new groups with characters and powers very different from those belonging to the previous groups, or to the individuals composing them. Individuals previously harmless or benign he will sometimes combine together, so as to form a band of poisonous murderers. Awkward and spiritless dolts he can associate, match, and arrange together in such a way as to develop in them high spirited and estimable qualities. By selecting, drilling, and arranging a lot of the most worthless and unattractive of things, he can turn out some of the most beautiful, useful, and valuable combinations that have in these times enriched the world. But besides the changes in regard to qualities easily recognized by our senses, such as color, taste, and smell, there are many other and more subtle changes which he can effect that are not so readily appreciated by us.

The exact *rationale* of these changes is, I suspect, almost beyond our comprehension. With regard to color, knowing as we do that Electron, if not identical with light, is allied and even superior to it, and may therefore be believed to have some command of those elementary colors contained in light, and it is quite conceivable that the molecules and the ultimate atoms of matter may have, through the influence of Electron, special affinities for certain of these colored elements, or specially electrized atoms, if such they be, as we know that they have for the other spectroscopic elements of light, and that they will, in consequence, reflect some but absorb others, appearing in that color which they reflect, and showing black if they absorb all, but white if the reflect them all.

So subtle and all-embracing is the essence of this great genie that there is no part of the world, or of what it contains, that is not more or less imbued with it. But, though embracing all things, he shows a decided preference for some above others, and this in so manifest a way that the magi who are devoted to his service have had no difficulty in making out a list of things in the order of his preference for them. Among those for which he shows the highest favor and attachment are the great family of the metals, and it is chiefly through their means that mankind have been enabled to become acquainted with his character and qualities, and with at least some of the laws by which he is governed in the work which God has ordained him to do. By their means it is, too, that his extraordinary powers are being more and more applied to the direct service and benefit of mankind. For example, while *we* can travel at the rate of a mile per minute along an iron railway, one of the same material, at a fraction of the cost, can be made to convey Electron, with whatever store of intelligence we choose to intrust to him, thousands of miles, and to any part of the world, in the same space of time.

(To be continued.)

ELECTRO MOTORS.

ALTHOUGH the technical journals in this country and abroad have frequently published paragraphs and descriptive illustrated articles on the telpherage system of Prof. Jenkin, we do not think it has yet been generally mentioned that the telpher lines supplied to South America and that for the Royal Agricultural Society's Show at Shrewsbury are worked in connection with the electro-motors designed by Mr. A. Reckenzaun.

We understand that Mr. Mylne of the Telpherage Company, representing Prof. Jenkin, has recently made some tests with a motor employed on the telpher line at Weston.

From the results given in the appended table it would appear that the Reckenzaun motors, considering their small size and comparative lightness, show a very fair efficiency. We are assured that there is not the slightest sparking at the commutator brushes, no matter at what speed the motor is revolving or even with the sudden and frequent reversals of current required in Prof. Jenkin's system.

These machines are provided with reversing gear, and weigh, complete, 117 lb.; they will work continuously up to 1·5 brake horse power, or, intermittently, to as much as 2 horse-power. Their dimensions are 16 inches long, 16 inches wide, and 8½ inches high; the resistance of the armature is 0·455 ohm and that of the field-magnets 0·090, giving a total resistance of 0·545 ohm between terminals.

The power tests were made by Prof. Jenkin's own dynamometer, the construction of which may be gathered from the sketches. It consists of a cast-iron V grooved pulley fixed on a shaft, C, by means of an American chuck, D, in order that it may be fitted to spindles of various diameters. A loose wooden pulley, B, having a well lubricated gun-metal boss, is threaded upon the motor spindle, C. The cord passing over the upper quarter of the circumference of the wooden pulley, B, is fastened by an eye, S, and carries the smaller weights, *p*. Another cord held by the bracket, E, which is fixed to the loose pulley passes over a quarter circumference of the iron (fast) pulley, A, and this chord with weights, P, determines the work absorbed by friction; the circumference of cord in this case = 3·09 feet.

By adding or removing weights on either cord, the speed or power can be varied. An advantage which this dynamometer has over the Prony brake is in the fact that no soap and water lubrication is required. The following table shows a few of the tests:

Rev. per min.	P—*p* lb.	H. P. dynamometer.	Current amperes.	E.M.F. volts.
2244	8·25	1·73	29·8	75 8
1934	8·25	1·53	29·4	69·9
1784	12·25	2·04	41·7	72·5
1300	9·5	1·15	31·5	52·3
996	9·75	0·91	31·9	60·1
548	11·75	0·60	36·5	37 3
428	11 25	0·45	35 2	31·8

$$\text{H. P.} = \frac{3{\cdot}09 \times \text{revolutions} \times (\text{P} - p)}{33{,}000}.$$

Do any of our readers know of an electro-motor weighing less than 160 lb., giving the same power and efficiency as the apparatus to which we have referred?

We may mention that these motors are manufactured by the Electrical Power Storage Company, Mr. Reckenzaun being highly satisfied with their construction both mechanically and otherwise.—*Elec. Review.*

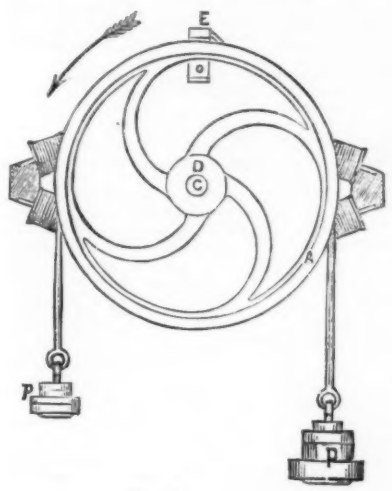


FIG. 1.

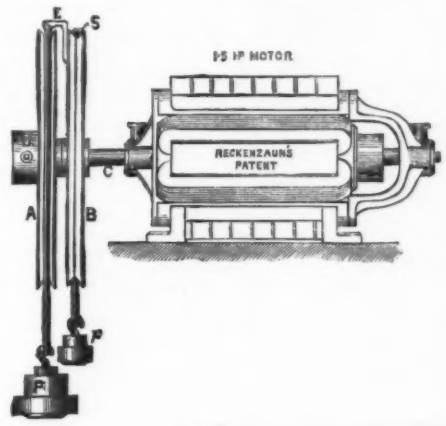


FIG. 2.

GEOMETRIC ORNAMENT.

By LEWIS F. DAY.

THE necessity for a geometric basis of ornamental design has been so rigidly insisted upon by departmental authority that the student is like to be irritated into opposition; all dogma cuts two ways. In one important division of design geometry is inevitable. Wherever, that is to say, a pattern is repeated a number of times, a geometric succession of the parts becomes apparent; and where this consideration of geometric order has not been duly considered, the result is often most disastrous. Suppose you commence without any idea of formal distribution, and merely design a scroll as graceful as may be—a series of such scrolls side by side will most likely show lines not in the least contemplated by the designer, and as inelegant as they are unexpected. So commonly is this the case, that it is really wisest to base your design upon some regular arrangement of lines which, if they should be apparent in the finished design, will at least be comely.

It is one of the strangest things in the experience of a designer to see the tricks his patterns will play him when repeated. A wall paper design, for example, which appears to be so evenly distributed as to show no leading features of any kind, will prove, when hung, to run in lines slanting so as to give the impression that the walls are not true, or that the paper has been hung askew. It is not impossible, of course, however difficult, to design an absolutely free scroll that shall yet conform to all decorative conditions, even when repeated many times over. But one thing is imperative, namely, that the parts which appear to balance one another should do so absolutely. If, for example, a scroll is reversed, the two sides of it should take identically the same curve, and any two corresponding flowers should be exactly on the same level. The main lines and more important features thus balancing one another, we may take what liberty we like with details which do not assert themselves; and it is always a charm in a design to find variations showing that the pattern has not been just traced and reversed; but it is the little difference in level, or the slight departure from the perpendicular, where the eye expects mechanical accuracy, that is in most cases responsible for unfortunate lines in repeated surface patterns.

If the repeat of your pattern is small, you naturally get all the variety you can get into it, knowing that repetition will bring with it quite enough of order and formality; but if you have a large space to cover, it is as well always, unless you wish it to present an absolutely uniform appearance, to settle points in it which shall be marked so as to form, as it were, links between the inevitable points which recurrence will reveal in the design.

As for ornament which is not merely based on geometric lines, but consists of geometric forms, it is very easy to have too much of it. Its most satisfactory use is perhaps to be found in mosaic, to which it seems naturally adapted, more especially where the colors are varied in an accidental manner, as is the case with marble and wood. Such accidental variation is, in fact, exactly what is necessary to geometric work. The unexpectedness of the tints just counteracts the certainty of the forms, and redeems the effect from mere mechanism. The very reverse of this fit relation of form to color is seen in the ordinary encaustic tile work, which seems somehow to be always harsh and common, even when the colors employed are not in themselves absolutely crude. At all events they are never sufficiently varied—perhaps it is not in the nature of the manufacture that there should be much variety; in which case the look-out is hopeless. Certain glazed Moorish tile work of this kind is not free from harshness and even crudity. Yet we see in Italian Giottesque decoration, which is mainly, so far as its ornamental detail is concerned, in imitation of the forms of geometric inlay, that even in flat painted work the color can be subdued to a key so admirably in accord with mechanical forms that literally the only fault to be found with it lies in its pretense. Perhaps the charm is largely due to the fact that the forms are not precisely mechanical, but put in with some freedom, and even with a sketchiness that would horrify the British workman. Time, too, has doubtless been kind. Still, there is the happy result, which is not without its lesson for us.

By the way, in the ornamental glass mosaic of Giotto's time we get the very perfection of relation between geometric form and glowing color. Nothing like harshness of form is possible with these little facets of glass, which catch the light at all manner of angles, and glitter according to their own bright will.

Lines of a more or less geometric character are so useful in ornamental design that one is bound to avail one's self of them. But there is always a danger in using them, lest they should assert themselves unduly. What admirable use Grolier, for example, made of them! Yet there are many of his bindings in which they stand too emphatically pronounced.

One has noticed in many an instance of old stained glass and painted decoration the satisfactory result of a portion of the design being worn away, or nearly so, hinting to us that it is not absolutely necessary that geometric forms should stand confessed in all their naked severity. It is quite possible, and quite permissible, to subdue if not to obliterate them here and there, so that the logical cohesion of the design exists, without the obvious stiffness which results from the preponderance of geometric forms.

There is a way of relieving the monotony of geometric design, used in Byzantine art (one sees it at Ravenna), by interspersing sprigs of very conventional foliage in the midst of interlaced strap work, which is very charming. But in Byzantine art this is scarcely necessary; so little mechanical are the forms that they are scarcely to be called geometric.

Some sort of geometric basis to a design gives scale, severity, and strength to it, so that, apart from any necessity there may be for repetition (which, of course, involves recurrence of the parts in geometric order), we habitually adopt it as an element almost indispensable in design.

The point to which geometric design has been carried by the Arabs is something really marvelous. Not so marvelous as it at first appears, for it seems at first as if human ingenuity could never so much as grasp the thread of such intricate pattern work, much less invent it—yet still sufficiently bewildering, even when one is familiar with the, after all, simple lines on which it is constructed. But even in such work as this, where geometric design certainly reaches its zenith, one cannot escape a certain weariness of interlacing lines and parts repeated; and a certain amount of wear and tear, and even of dilapidation, is a relief to the eye. I have always found the greatest pleasure in examples that, whether by design or accident, are not altogether mechanical in execution.

This brings me to the conclusion which has pressed itself upon my conviction, that it is the geometric distribution of ornament which is valuable, while geometric accuracy of execution is not merely worthless, but fatal to ornament. Why is it that modern Gothic tracery is apt to be so hideously hard compared to the old examples from which it is copied? Simply that it is what the builder calls "true," which the old work is not, and probably never was. Even in old work, whose edges have been softened by time, what a relief it is to get away from the evidence of mechanism! In German geometric tracery one is conscious of the part played by the compasses in the design; and in English perpendicular work, there is always a suggestion of the T square; but in French flamboyant forms one sees only the artist. There is a geometric relation of the parts, but the lines flow freely from the hand of the designer.

Great importance has sometimes been attached to the construction of ornament, not only on a geometric basis, but upon the principle of the multiplication of one simple unit throughout. It is quite true that a great deal of Arab and Moresque pattern work is reducible, for all its intricacy, to the simplest possible elements; and that star shapes, diamond forms, hexagons, and other polygons are all multiples of the simple triangle upon which this particular variety of Eastern design appears to be built up. But I am not so certain that it is altogether a building process with the Oriental designer. When you come to deal with absolutely geometric shapes, the subdivision of such shapes into similar geometric divisions is almost a natural instinct, with any one whose ingenuity lies at all in the direction of such art. The space to be ornamented, suggests, in fact, its being broken up into segments of like shape. The square, for example, suggests a smaller square set anglewise within it, and the resulting triangles at the corners suggest, again, a triangle placed in the same way in its center, dividing the space into four equal equilateral triangles. Whether, however, the design be the result of a process of multiplication or division of parts, matters little; except that too much stress has been laid, I think, upon this constructive form of design. No doubt the construction is there; and there is significance in the fact. But I fancy that the Mohammedan artists were not always thinking of the principle underlying their work, even if they were always conscious of it. Their art was traditional and instinctive to a degree. And, anyway, I disbelieve entirely in the advisability, and even in the possibility, of our designing on any such scientific principles as may doubtless be discovered in Alhambresque design. It is possible, very likely, mathematically, to reconstruct the subtlest curves of Greek architecture; but does any one imagine that they are the outcome of mathematical science? A scientist perhaps! I have heard such a one enthusiastic in the anticipation of a time when color shall be reduced to a matter of mathematical certainty—in which case it will be about as interesting as a game of chess where, one move made, the rest follow as if the human machines engaged in it had been wound up. Art proceeds, happily, upon quite different lines. And though the results of art may be scientifically explained perhaps, the effects of art are not to be scientifically produced.—*The Architect.*

A HINT TO SHIPPERS OF APPLES.

AN English agricultural paper prints some excellent advice to American apple growers. In the first place, it complains of a kind of two and three-quarters bushel barrel, which is extensively used in New York, and advises all who wish to ship fruit to England to use the old-fashioned three-bushel barrel, with an honest bulge. Then it alludes politely, but plainly, to the American habit of sorting the fruit, and stowing the second rate article in the middle of the barrel, while the red cheeked, plump apples are invariably placed in the exposed ends. The apple packers of New England will do well to ponder on these remarks, for they are good. Let them check their inclination to place the pleasant faces of their apples all on the outside, and rest assured that if they can get a reputation for honest sorting, their reward will be substantial.—*Advertiser.*

PHYSICS WITHOUT APPARATUS.

Equilibrium of Floating Bodies.—The equilibrium of bodies floating upon liquids is an occurrence of daily observation, but such is not the case as regards seriform fluids—a soap-bubble filled with air and floating upon a stratum of carbonic acid, for example. Although this pretty experiment would seem to require complicated apparatus to carry it out, it may nevertheless be performed very simply, as follows:

Having procured a glass vessel, such as a bell-glass, of medium size, place it, mouth upward, upon a tripod made of coarse wire, or upon any other support. In the bottom of this vessel place a mixture formed of equal parts of bicarbonate of soda and tartaric acid reduced to powder. The quantity of powder to be employed depends upon the size of the vessel and the thickness of the stratum of carbonic acid that it is desired to have. Bicarbonate of soda contains carbonic acid to the amount of half its weight, and consequently it is necessary to decompose four grammes (66 grains) of bicarbonate to produce one liter (61 cubic inches) of carbonic acid gas.

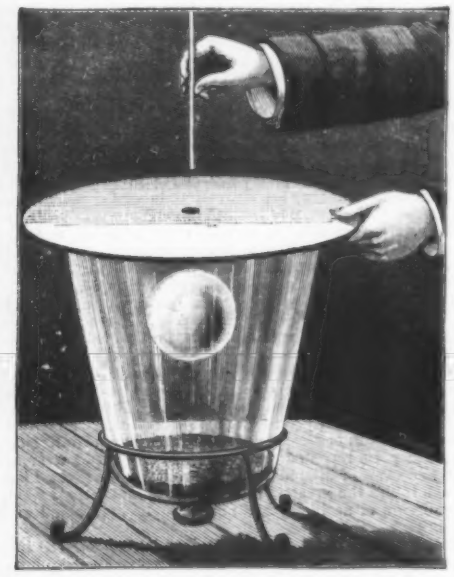


FIG. 1.—SOAP BUBBLE FLOATING UPON A STRATUM OF CARBONIC ACID.

Over the mouth of the glass vessel place a disk of cardboard of sufficient size to cover it exactly, and, in the center of this, make a circular aperture to allow of the passage of a glass rod of sufficient length to rest upon the bottom and project externally. Through this tube, and by means of a small funnel, water is introduced in small quantities at a time (so as not to produce too lively an effervescence) until the powder is entirely covered. When the carbonic acid ceases to be given off, the tube is taken out.

Care should be taken to prepare beforehand a solution of soap in water, or, what is better, some of Plateau's glyceric liquid. With either of these liquids, bubbles about 10 centimeters in diameter are blown at the extremity of a tube that flares slightly. This tube should be held vertically while carrying the bubble over the cardboard cover, and the latter should be carefully removed by sliding it off horizontally, and the bubble be then detached in such a way that it shall fall in the direction of the vessel's axis. If the fall occurs from a certain height, the ball will rebound as if it were repelled by a spring. It will then descend and rise again, and finally become immovable. It is at this moment that it is well to replace the cover, so that no disturbance shall occur in the interior of the vessel.

The bubble then resembles a small balloon in equilibrium in the atmosphere of the vessel; but, in reality, it is floating upon the invisible stratum of carbonic acid. This equilibrium, however, is of short duration, since the carbonic acid rapidly dissolves in the liquid envelope of the bubble, and passes into the interior of the latter, and increases its weight to such a degree as to cause it to gradually descend to the bottom of the vessel, where it disappears. But a suspension of several balls may be obtained successively, that is to say, the experiment may be repeated several times, if, on removing the cover, care be taken not to disturb the atmosphere of the vessel.

The soap bubble may be replaced by one of those small rubber balloons that please children so much, and that weigh, on an average, one gramme each. Upon inflating one of these to a diameter of about 15 centimeters, we shall obtain an equilibrium that has greater fixedness and duration, and may observe the phenomenon at our leisure.

Aside from its attractiveness, the experiment under consideration may furnish a subject for interesting calculations. Thus, we may suppose (1) that the bell glass is replaced by an inverted geometrical cone whose generatrix makes an angle of 30° with the vertical axis; (2) that the mixture of salts and water serving to produce the gas occupies a height of 15 centimeters at the bottom of the cone; (3) that it concerns the preparation of a volume of gas that shall form above the preceding mixture a stratum 20 centimeters in thickness, and whose weight shall be estimated at a temperature of 15° C. and under an atmospheric pressure of 748 millimeters.

Then, from the chemical equivalents, may be determined the quantities of bicarbonate of soda and tartaric acid that are to be mixed in order to produce the required weight of carbonic acid.

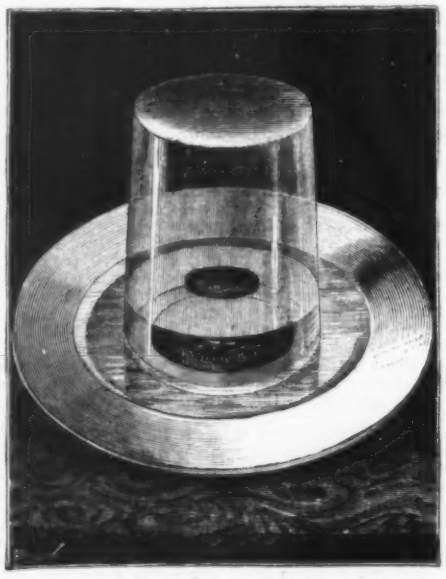


FIG. 3.—EXPERIMENT ON REFRACTION.

Finally, upon assigning a diameter of 0·15 m. and a weight of 0·85 gramme to the small spherical balloon, and admitting that the stratum of carbonic acid terminates in a clearly limited horizontal plane when the equilibrium of the floating balloon is effected, a calculation may be made of the ratio that exists between the part immersed in the carbonic acid and the part external to it. Such calculations, as may be seen, may be considered as good exercises for study.

Experiment on Atmospheric Pressure.—Take a thin piece of wood about an eighth of an inch thick, 8 inches wide, and 24 inches long, and lay it upon a table so that it shall project over the edge. It is evident that the least pressure will make it tilt and fall. Next spread out a large newspaper over the end that lies upon the table. Now if you strike a sharp blow with your fist on the projecting portion, you will be much surprised to see that the board resists the shock, just as if it were nailed to the table. If you strike hard you may injure your hand, or perhaps the board will break into pieces, but you will not lift the simple paper that holds it. The downward pressure of the atmosphere upon a wide surface explains the phenomenon. In order that the experiment may succeed well, the paper should be spread flat and evenly upon the table, and all the folds should be smoothed out so as to expel the interposed air.

Experiment on Refraction.—This experiment requires an ordinary glass, a plate, a little water, a 2 franc piece, and a chemical match. It may be presented under a pleasing form and give a solution of the astonishing problem of how to cause 7½ francs to be seen with 2 francs!

Take the 2 franc piece and place it in the center of a plate containing enough water to cover it. After this, take an ordinary drinking glass, and turn it bottom upward and heat the interior with a lighted match. When the internal air becomes hot, place the glass over the 2 franc piece in the plate (Fig. 3). As a consequence of the contraction of the hot air in cooling, and of the pressure of the atmosphere, the water will rise slightly in the glass. Now if you look at the surface of the liquid you will see two pieces of money; first, the 2 franc piece, and, second, a little beneath it, a larger piece having the aspect of 5 francs. Finally, as the bottom of the glass forms a divergent lens, if you look into it from above you will see a reduced image of the 2 franc piece, looking for all the world like a 50 centime one. So 2 francs, 5 francs, and 50 centimes make 7½ francs, and the problem is solved.

In this amusing experiment there are several points of physical instruction for children, viz., expansion of the air by heat, contraction of the heated volume by cooling, ascent of the liquid into the glass through atmospheric pressure, refraction, and divergence of the luminous rays by a lens. Such are the different phenomena which succeed one another, and which a professor can analyze with all the extent necessary.—*La Nature.*

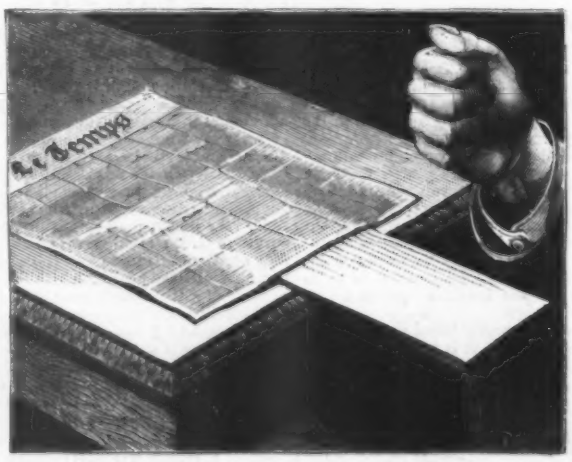


FIG. 2.—EXPERIMENT ON ATMOSPHERIC PRESSURE.

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